Preliminary Guidelines for Population-level Abundance, Productivity, Spatial Structure, and Diversity Supporting Viable Salmonid Populations:

An Update

Interior Columbia Basin Technical Recovery Team

12/13/04

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Purpose and Scope of this Document

In this document, we present an update on population-level viability criteria for Interior Columbia ESU listed salmon and steelhead populations. This update supplements our draft document *Viability Criteria: Summary of Approach and Preliminary Results* (*8/05/04*). It provides:

1. Specific examples of viability curves, which serve as a gauge of risk for combinations of abundance and productivity.
2. Specific metrics and preliminary criteria describing population-level risk associated with spatial structure and diversity.

The additional detail provided in this document serves two purposes. First, and primarily, the specific metrics we provide will inform recovery planners and others involved in Interior Columbia salmon conservation efforts about specific factors and metrics that the TRT currently believes should be included in efforts to consider a population's abundance, productivity, spatial structure, and diversity. These metrics may be refined in the future; however, they capture the fundamental elements of the four viability parameters. Second, the preliminary criteria offered here will inform conservation planners of the current IC-TRT concept of specific population-level characteristics associated with different risk levels. In other words, this effort describes more explicitly the meaning of "adequate abundance, productivity, spatial structure and diversity to support a viable salmonid population." **Importantly, these criteria are preliminary: they may be refined or modified in response to new information, analyses or review.** Given the pace and schedule of current recovery planning efforts in the interior Columbia Basin, particularly in Washington State, we offer these criteria at this early stage in order to provide conservation planners with a sense of the scope and magnitude of effort that will likely be required to achieve viability.

While this document does provide a significantly greater level of detail about factors that should be considered for meeting individual requirements, it does not expand on other issues important for overall population and ESU-level viability. For instance, it does not provide guidelines for integrating across each of these parameters to generate an overall population-level risk rating. In addition, we are currently working to develop further guidance to improve our MPG- and ESU-level criteria.

Differential Intrinsic or Historical Risk between Populations

Due to natural differences between populations in habitat quantity, stream topology, and stream structure, in the past, populations likely experienced different risk levels, even in their most pristine state. For this reason, when appropriate, we tailored our criteria to size categories (for abundance and productivity) and structural categories (for spatial structure and diversity). Thus, large, spatially complex populations have different viability criteria than small, simple populations. See Attachment A for our preliminary categorizations.

Abundance and Productivity

The ICTRT has developed a set of generalized viability curves using variance estimates derived from return-per-spawner data sets (expressed in terms of spawner-to-spawner ratios). We used two alternative approaches to using spawner data series to generate viability curves: return per spawner (Figure 1a) and annual population growth rate based on running sums (Figure 1b).[1] Both approaches are based on statistics generated from representative time series of annual spawner estimates. In addition to depicting the 5% risk of extinction threshold for evaluating population viability, the figures also include risk thresholds corresponding to a relatively high risk of extinction (25% in 100 years) and a lower risk level (1% in 100 years).

The ICTRT focused on examples of viability curves based on direct measures of abundance and productivity. It is possible to express the productivity term in a viability curve in terms of stock-recruitment functions, e.g., Beverton-Holt or Ricker curves. In most cases, data used to evaluate current status will be based on a relatively limited number of years. Uncertainty levels and bias in parameter estimates can be very large. Status assessments that use fitted stock recruit curve parameters as an index of current productivity should directly incorporate considerations for sampling induced errors and bias in their assessments.

The viability curves are defined using a specific risk metric, no more than a 5% probability of decreasing to below 50 spawners per year for a generation (typically 4 to 5 years) in a 100-year period. The example curves are based on average estimates of population variability for the major groupings and/or ESUs. Under historical conditions, most populations within the region would have been rated as very low risk relative to the 5% viability curve. At the population level, recovery strategies should be targeted to achieving combinations of abundance and productivity above the 5% viability curve threshold.

The TRT is also investigating the use of metrics at other life stages, including juvenile productivity. Adding specific measures that reflect survival from spawning to outmigrating smolt and from outmigrant to adult return would address a major confounding factor, high year-to-year variability in marine survival rates. Incorporating smolt production measures would also aid in evaluating tributary habitat effects.

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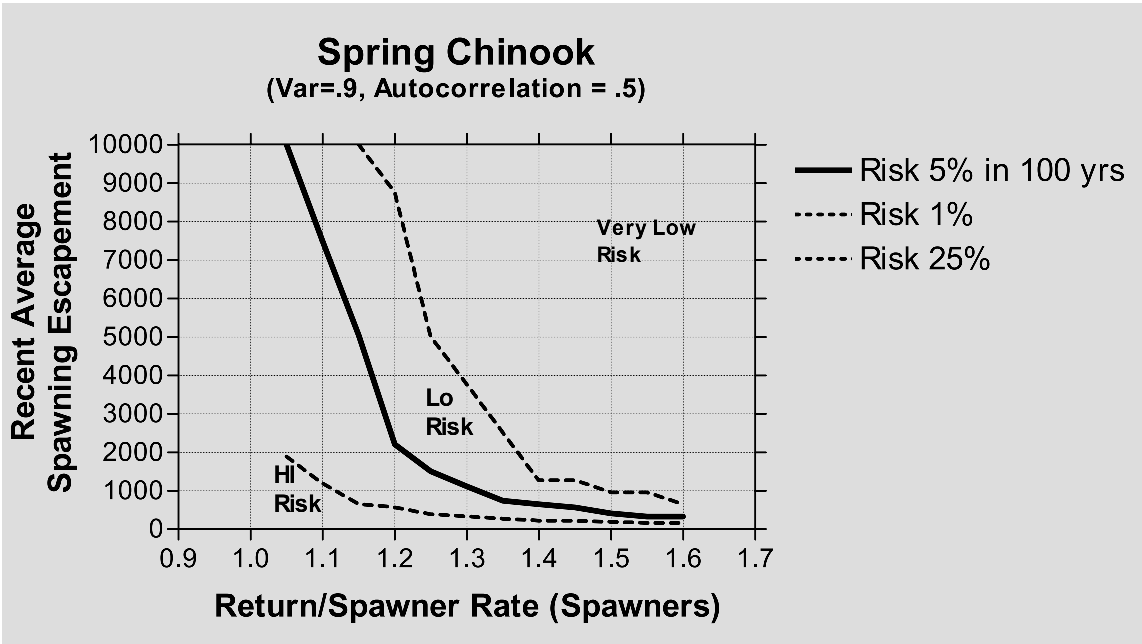
[1] See Holmes (2001) for a description and rationale for the Running Sums approach.



(b) Running sum based annual population growth-rate model.

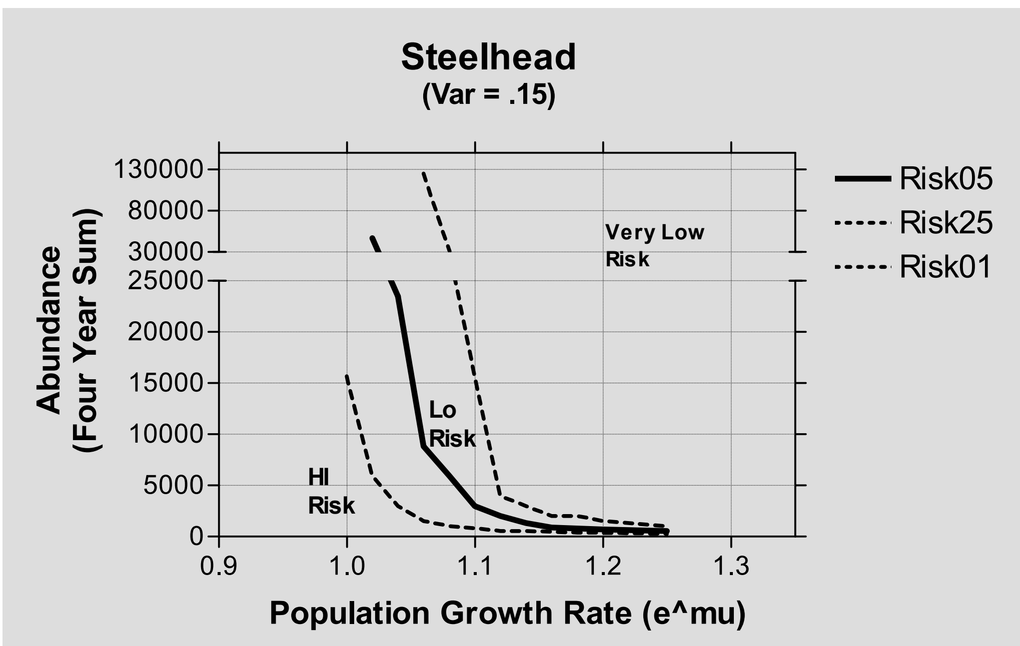


Figure 1. Examples of viability curves using alternative measures of abundance and productivity, average population variance/covariance estimates.

Adjustments for Population Size

Populations of listed Chinook salmon and steelhead within the Interior Columbia River vary considerably in terms of the total area available to support spawning and rearing. The ICTRT developed a method for adapting viability curves to reflect estimates of the historical amount of potentially accessible spawning and rearing habitat available to a specific population. A more detailed description of the approach is provided in Attachment B.

In summary: A measure of spawning/rearing area used to index the population spawning/rearing areas is generated using a simple model of historical intrinsic potential. That model is driven by estimates of stream width, gradient, and valley width derived from a GIS-based analysis of the tributary habitat associated with each population. Each accessible 200-m reach within the tributary habitat associated with a specific population is assigned an intrinsic productivity rating based on the particular combination of physical habitat parameters listed above. Four categories were used: high, moderate, low, and not rated or zero potential. A weighted estimate of the total amount of rated habitat historically available to each population was constructed by summing the habitat by rating category, multiplying each sum by a relative weighting factor (1 = high, .5 = moderate, and .25 = low), and totaling the weighted sums. Populations are assigned to one of three size/complexity categories based on the total amount of weighted spawning habitat: basic, intermediate, and large (Attachment A).

The ICTRT is developing additional information for use in comparing the status of individual populations against abundance and productivity criteria. The approach we are developing requires comparing estimates of recent abundance and intrinsic productivity against viability curves generated using species-specific average variance and age structure parameters. The curves are modified by abundance thresholds specific to population size categories (500, 1,000, and 2,000 for basic, intermediate, and large populations). An example of applying the basic viability curve to populations classified as large is provided in Figure 3.

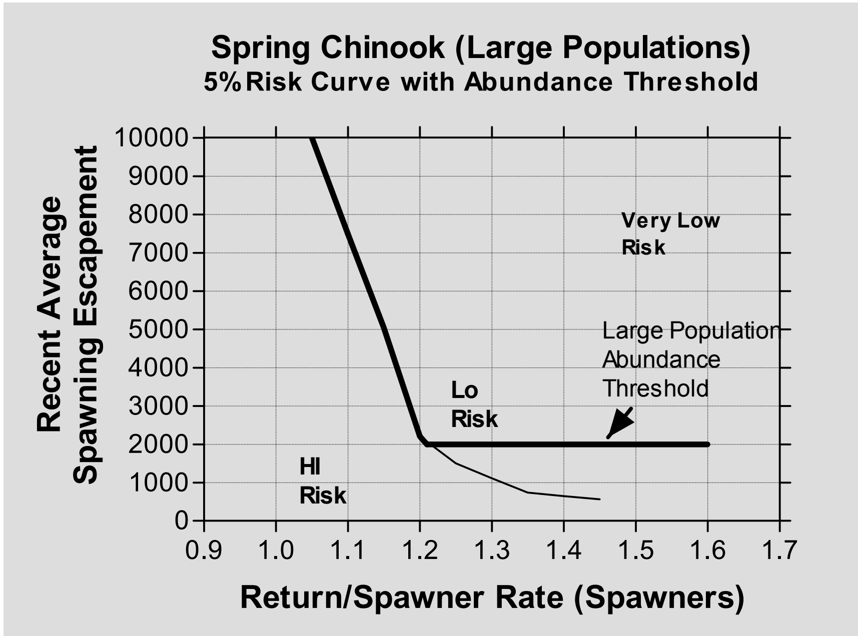


Figure 2. Example of a viability curve with abundance threshold for application to large populations.

Spatial Structure and Diversity

Goals, Mechanisms, Factors and Metrics

In our previous document, we combined all the spatial structure and diversity viable salmonid population (VSP) guidelines into a hierarchical format that outlines the goals, mechanisms to achieve those goals, and examples of factors to be considered in assessing a population's risk level. We then provided some examples of scenarios leading to various levels of risk. In this document, we use the same structure (slightly modified from our original document to better reflect our current thinking), but present metrics appropriate for assessing population status with respect to each mechanism, and ultimately with respect to our biological goals. For clarification, we present the following definitions:

- A *goal* is the biological or ecological objective that spatial structure and diversity criteria are intended to achieve. We have identified two primary goals:
    1. Maintaining natural rates and levels of spatially-mediated processes. This goal serves to minimize the likelihood that populations will be lost due to local catastrophe, to maintain natural rates of recolonization within the population, and to maintain other population functions that depend on the spatial arrangement of the population. [Note: we are currently looking for an alternative phrase to describe this goal. Suggestions are most welcome.]
    2. Maintaining natural patterns of variation. This goal serves to ensure that populations can withstand environmental variation in the short and long terms.
- *Mechanisms* are biological or ecological processes that contribute to achieving those goals (e.g., gene flow patterns affect the distribution of genotypic and phenotypic variation in a population).
- *Factors* are characteristics of a population or its environment that influence mechanisms (e.g., gaps in spawning distribution affect patterns of gene flow, which then affect patterns of genotypic and phenotypic variation). In some cases the same factor can affect more than one mechanism or goal. The distribution of spawning areas in a branched vs. a linear system, for example, can affect both patterns of gene flow *and* the patterns of spatially mediated processes, such as catastrophes.
- *Metrics* are measured and assessed at regular intervals to determine whether a population has achieved goals, or to evaluate its current risk level. Each factor has one or more metrics associated with it.
- *Criteria* are specific values of metrics that indicate different risk levels.

We summarize the association between goals, mechanisms, factors and metrics in Table 1. When a factor affects more than one mechanism, we listed it under the mechanism for which it is most directly relevant.

Table 1. Considerations for spatial structure and diversity criteria at the population level. Examples are not exhaustive.

Goal	Mechanisms to Achieve Goals	Factors	Metrics
A. Allow natural rates and levels of spatially mediated processes	1. Maintain natural distribution of spawning aggregations	a. Number and spatial arrangement of spawning areas	Number and distribution of major and minor spawning areas (see Attachment C for definition)
		b. Spatial extent or range of population	Proportion of historical range occupied by population Presence/absence of spawning in MSAs
B. Maintain natural variation	1. Maintain natural genotypic and phenotypic expression	a. Major life history strategies	Presence/absence and distribution of major life history strategies within a population
		b. Other phenotypic variation	Distribution of other phenotypic variation within a population
		c. Genetic variation	Within- and between-population measures of genetic differentiation (e.g., Fst, heterozygosity, allele frequencies, etc.)
	2. Maintain natural patterns of gene flow	a. Spawner composition	Proportion and origin of non-local spawners
		b. Increase or decrease in gaps or continuities between spawning aggregates	Distance between spawning aggregates
	3. Maintain occupancy in a natural variety of available habitat types	a. Distribution of population across habitat types	Habitat diversity index (see Attachment D)
	4. Maintain integrity of natural systems	a. Change in natural processes or impacts	Selectivity score for impacts (qualitative or quantitative)

Again, we believe that the inherent resilience of the population to perturbations in part depended on its natural setting. Therefore, we devised categories encompassing the range of natural structures seen in salmonid populations in the interior Columbia Basin (Table 2). Preliminary assignment of specific populations to categories can be found in Attachment A. We intend to undertake a more systematic assignment in the near future.

Table 2. Structural categories for salmonid populations in the interior Columbia Basin. Populations are categorized according to their likely natural or intrinsic condition, rather than current distribution.

Category	**Description**
A.	Small-intermediate drainage, linear structure or 1-2 branches
B.	Intermediate to large drainages, dendritic tributary structure, 2 or more major spawning areas
C.	Trellis-structured drainage, mainstem spawning, multiple small or large tributaries to main stems.
D.	Populations with one or more "core tributary" spawning areas coupled with adjunct, but separated, downstream small tributaries

We have drafted preliminary criteria for each metric, where appropriate, tailored to each category. *Again, these preliminary criteria may change in response to new information, analysis, or review. They are intended as information for planners to gauge the relative scope and magnitude of effort that will be required to achieve viability goals.*

Preliminary Criteria

Goal A: Allowing natural rates and levels of spatially-mediated processes

Mechanism A.1. Maintain natural distribution of spawning aggregates

Factor A.1.a. Number and spatial arrangement of spawning areas. We have defined major spawning areas (MSAs) as contiguous areas of habitat of sufficient quality and quantity to support a minimum number of spawners (see Attachment C) separated from other such areas. Our criteria depend on the number and arrangement of MSAs and other spawning habitat (Table 3).

Table 3. Preliminary criteria describing risk levels associated with the number and spatial arrangement of spawning areas.

	Pop.	Risk level			
Factor/metric	Group	Very Low	Low	Moderate	High
Factor: Number and distribution of spawning areas Metric: Number of MSAs, distribution of MSAs, and quantity of habitat outside MSAs	A B C D	4 or more MSAs in a non-linear configuration separated by >2 confluences; or 3 MSAs plus the sum of the other areas outside of MSAs with 75% capacity of an MSA	2-3 MSAs in a non-linear population separated by 1 or more confluences	Linear with capacity for 1 or more MSAs in linear configuration; or 1 MSA plus one or more branches (outside of MSA) that sum to greater than 75% of capacity of an MSA	Linear, single MSA, or single MSA with 'other' areas branched or linear that contribute less than 75% of an MSA; or Branched MSA with no source area (capacity < 500)

Factor A.1.b. Spatial extent or range of population. Reductions in the range of habitat used by a particular population can affect its vulnerability to local catastrophes. Any change in range that increases or decreases the distance among populations may alter exchange of individuals between populations, hampering the exchange of genetic materials within an MPG and/or an ESU, and altering the likelihood of recolonization of extirpated areas. We use two metrics to assess population range: 1) the proportion of the likely historical range as described by an analysis of intrinsic potential (Cooney et al. 2004), and 2) presence/absence of spawners in MSAs (Table 4).

Table 4. Preliminary criteria describing risk levels associated with spatial extent or range of population.

Factor/ Metrics	Pop. Group	Risk Level			
		Very Low	Low	Moderate	High
Factor: Spatial extent or range of population Metrics: Proportion of historical range occupied	A	Not attainable	Current spawning distribution mirrors historical (over 10 or more years compared to Intrinsic Potential mapping.)	Historical range reduced: Absence of spawners from 25% -50% of the habitat within the historical distribution (IP mapping.)	Historical range reduced: Absence of spawners from 50% or more of the habitat within the historical distribution based on intrinsic potential analysis.
Presence/ absence of spawners in MSAs	B C D	Population supports 3 or more MSAs AND Current spawning distribution mirrors historical (observations over 10 or more years compared to intrinsic potential mapping).	Historical range reduced: Absence of spawners from 20% or less of the habitat of the historical distribution based on intrinsic potential analysis.	Historical range reduced: Absence of spawners from 25%-50% of the habitat within the historical distribution based on intrinsic potential analysis OR Absence of spawners from 25% or more of historical MSAs	Historical range reduced: Absence of spawners from 50% or more of the habitat the historical distribution based on intrinsic potential analysis. OR Absence of spawners from 50% or more of historical MSAs

Goal B: Maintaining natural levels of variation

Mechanism B.1: Maintain natural patterns of phenotypic and genotypic expression

This mechanism focuses directly on observed genotypic and phenotypic variation within populations and on changes in that variation. This is the variation that we seek to preserve in viable populations. Changes in these natural patterns are the strongest possible evidence that the population may be at risk with respect to diversity.

Factor B.1.a. Major life history strategies. In general, a major life history strategy includes a suite of phenotypic characteristics that are relatively distinctive from other such strategies. Examples include "race" (such as spring- or summer-run in the Snake River spring/summer Chinook salmon ESU) or residence and anadromy (such as seen in steelhead and sockeye salmon). Although life history strategies are a subset of phenotypic expression, we did not include this factor within "phenotypic variation" because we felt that these suites of characters were particularly important for overall population viability. Our metrics for this factor include the presence and distribution of these life history strategies within a population (Table 5).

Table 5. Preliminary criteria describing risk levels associated with major life history strategies.

Factor	Pop. Group	Risk Level: Very Low	Low	Moderate	High
Factor: Major life history strategies Metric: Distribution of major life history expression within a population	A B C D	No evidence of loss in variability or change in relative distribution	All historical pathways present, but variability in one reduced and relative distributions shifted slightly	Significant reduction in variability and substantial change in relative distribution	Permanent loss of major pathway (anadromy for *O. mykiss*, race of Chinook salmon, or loss of a juvenile pathway)

Factor B.1.b. Phenotypic variation. This factor includes morphological, life history, and behavioral traits. Loss or severe truncation of specific traits reduces the resilience of a population to environmental perturbations, both in the short term (annual fluctuations, multiyear cycles) and long term (shifts in climatic conditions, etc.). We assess change in phenotypic variation by examining the mean, variation, and presence/absence of each trait (Table 6).

Table 6. Preliminary criteria describing risk levels associated with change in phenotypic characteristics.

Factor/Metrics	Pop. Group	Risk Level: Very Low	Low	Moderate	High
Factor: Phenotypic characteristics. Metric: Reduction in variability of traits, shift in mean value of trait, loss of traits.	A B C D	No evidence of loss, reduced variability, or change in any trait	Evidence of change in mean or variability in 1 trait (e.g., migration timing, age structure, size-at-age)	Loss of 1 trait or evidence of change in mean and variability of 2 or more traits	Loss of 1 or more traits and evidence of change in mean and variability of 2 or more traits (e.g., loss of a spawning peak and significant reduction in older age fish)

Factor B.1.c. Genetic variation. This factor addresses observed changes in genetic variation, regardless of the cause of that change (e.g., whether the change is due to introgression from non-local hatchery spawners or from the adverse genetic consequences of small population size). We did not include specific genetic metrics or cutoffs in our table of criteria due to the ever-changing nature of molecular genetic techniques and analyses. In addition, the wide variety of circumstances in the interior Columbia Basin requires a case-by-case examination of genetic data. For instance, available baseline genetic information may not be a reasonable picture of natural levels of genetic variation due to bottlenecks the population has experienced. We thus recommend that populations be evaluated for change from a baseline data set in:

- the amount of genetic variation detected within the population or subpopulations,
- the level of differentiation between subcomponents of the population, and
- the level of differentiation between the population and other populations (including hatchery stocks).

These changes may be expressed as statistically significant reductions in heterozygosity, number of alleles, changes in allele frequencies, or other relevant measures. Changes in any of these metrics will have to be evaluated within the context of the population's history to gauge the likely magnitude of change from natural patterns of genetic variation (Table 7).

Table 7. Preliminary criteria describing risk levels associated with change in patterns of genetic variation.

	Pop.	Risk Level			
Factor	Group	Very Low	Low	Moderate	High
Factor: Genetic variation Metric: Genetic analysis encompassing within and between population variation	A	No change from actual or presumed historical conditions	No change from actual or presumed historical conditions	Low level of change from actual or presumed historical conditions restricted to a single MSA	Moderate or greater level of change from actual or presumed historical conditions in any MSA
	B	No change from actual or presumed historical conditions	Low level of change from actual or presumed historical conditions restricted to a single MSA	Moderate or greater level of change from actual or presumed historical conditions in 1 or up to 25% of MSAs (whichever is smaller)	Moderate or greater level of change from actual or presumed historical conditions in 2 or greater than 25% of MSAs
	C	No change from actual or presumed historical conditions	No change from actual or presumed historical conditions	Low level of change from actual or presumed historical conditions restricted to a single MSA	Moderate or greater level of change from actual or presumed historical conditions in any MSA
	D	No change from actual or presumed historical conditions	Criteria for A or B populations, dependent upon number of MSAs in population	Criteria for A or B populations, dependent upon number of MSAs in population	Criteria for A or B populations, dependent upon number of MSAs in population

Mechanism B.2: Maintain natural patterns of gene flow

Maintaining natural patterns of gene flow is an indirect means of maintaining natural patterns of variation. We identified two important factors supporting this mechanism.

Factor B.2.a. Spawner composition. Because measures of genetic change may not be available or may lag behind the initiation of change, we also include spawner composition as an important factor affecting gene flow. We have developed preliminary risk criteria for local-origin hatchery spawners and hatchery spawners of exogenous origin (Table 8). Although we have not yet developed criteria for changes in the proportion of out-of-population spawners of natural origin, this is also a risk: any changes in the proportion of exogenous spawners should also be considered.

Table 8. Preliminary criteria describing risk associated with spawner composition for local-origin hatchery spawners and non-local-origin hatchery spawners.

Factor/Metrics	Pop. Group	Risk Level			
		Very Low	Low	Moderate	High
Factor: Spawner composition, local-origin hatchery fish. Metric: Proportion of natural spawners that are hatchery fish, life history similarity, proportion of broodstock that is of natural origin, degree of selectivity in broodstock collection.	A	0%	1 generation less than 50% of spawners	1-3 generations with low-high proportion of spawners Life history similar, non-selective broodstock collection, high proportion of natural spawners in broodstock	Multiple generation program High proportion of broodstock and natural spawners of hatchery origin Life history differences (age structure, run timing) Selective collection of broodstock
	B	0%	1-3 generations less than 50% in target MSA and less than 10% in all non-target MSAs Broodstock representative of target MSA	1-3 generations low-high proportion in target MSA (best broodstock management practices) and 10% or greater in any non-target MSA OR greater than 3 generations in target, less than 10% in non-target MSA(s)	Greater than 3 generations low-high proportion in target MSA and 10% or greater in non-target MSAs
	C	Use criteria for Category A populations if branches are linked to mainstem by gene flow. Use criteria for Category B populations if branches have little gene flow with mainstem.			
	D	0%	1-3 generations less than 50% in target MSA and less than 10% in all non-target MSAs	1-3 generations low-high proportion in target MSA and 10% or greater in any non-target MSA	Greater than 3 generations low-high proportion in target MSA and 10% or greater in non-target MSAs

Factor/Metrics	Pop. Group	Risk Level			
		Very Low	Low	Moderate	High
Factor: Spawner composition, non-local origin hatchery strays with similar spawn timing. Metric: Proportion of natural spawners that are hatchery strays.	A B C D	0%	1-2% for 1-2 generations	2-10% for 1-2 generations	10% or greater for more than 2 generations
Factor: Spawner composition, change in proportion of non-local natural-origin spawners	A B C D	To be Developed			

Factor B.2.b. Increase or decrease in gaps or continuities between spawning aggregates. Given the strong homing instincts of anadromous salmonids, significant changes in the distance between spawning areas may have impacts on gene flow within and among populations. The size of gaps between spawning areas may also affect the ability of a population to recolonize extirpated areas, and is thus relevant for our Goal A as well. A general dispersal distance relationship was used as one factor in defining distinct historical populations within Interior Basin ESUs. Based on that curve, dispersal or straying rates between spawning areas less than 10 km apart were relatively high. We suggest a simple index based on that dispersal relationship--increases of 5 km or more in separation among MSAs (Table 9).

Table 9. Preliminary criteria describing risk associated with an increase or decrease in gaps or continuities between spawning aggregates.

Factor/ Metrics	Pop. Group	Risk Level			
Factor: Increase or degrease in gaps or continuities between spawning aggregates. Metric: Change in gap distances and spawner distribution.	A	Not attainable	Not attainable	Like historical	Development of a 5-km or greater gap that did not exist historically
	B C D	Like historical	Gaps increased by 1 km or less	Gaps increased 2-5 km	If 3 MSAs or less, then gaps increased by 5 km or more between 2 MSAs. If greater than 3 MSAs, then gaps increased by 5 km or more in 50% or more of nearest neighbor MSA pairs

Mechanism B.3: Maintain occupancy in a natural variety of available habitat types

Maintaining spawner occupancy in a natural variety of available habitat types is an indirect mechanism to maintain natural patterns of variation. We assume that differing habitats allow or promote the expression of differing phenotypes. Conceptually, the greater the range of habitat types available, the greater the potential for a population to express phenotypic diversity.

Factor B.3.a. Distribution of population across habitat types. We use a habitat diversity index (HDI) to assess the range of habitat types occupied. Our HDI is calculated at the population level and incorporates five habitat features linked to phenotypic and life history characteristics, either empirically or conceptually: elevation range, range of stream widths, Shreve stream order as an index of branching, precipitation patterns as a surrogate for hydrograph patterns, and distribution of spawning areas across ecoregions as a general indicator of habitat differences. Each of these five factors is equally weighted in the index. We present current values for each population in Attachment D. The ICTRT is currently conducting analyses to further refine this metric. Because populations inherently differ in the range of habitat types present, we use potential or historical habitat types as a benchmark, and deviation from the historical condition as a measure of risk (Table 10).

Table 10. Preliminary criteria describing risk associated with distribution of the population across habitat types.

Factor/ Metrics	Pop. Group	Risk Level			
		Very Low	Low	Moderate	High
Factor: Distribution across habitat types. Metric: Habitat diversity index and occupancy.	A	Not attainable	Greater than 90% of historic conditions must be met	10-20% reduction in diversity metric	20% or greater reduction in diversity metric
	B	0-10% reduction in diversity metric	10-20% reduction in diversity metric	20-50% reduction in diversity metric	Loss of occupancy of 1 major ecoregion OR 50% or greater reduction in diversity metric
	C	Not attainable	0-10% reduction in diversity metric but not exclusively in tributaries or mainstem	10-20% reduction in diversity metric but not more than 10% in either tributaries or mainstem	Greater than 20% reduction in overall diversity metric OR entire loss of either tributary or mainstem area
	D	Not attainable	0-10% reduction in core area diversity metric AND at least 50% of adjunct areas suitable for occupancy	10-20% reduction in core area diversity metric AND 25-50% of adjunct areas suitable for occupancy	Greater than 20% reduction in core area diversity metric AND less than 25% of adjunct areas suitable for occupancy

Mechanism B.4. Maintain integrity of natural systems

Maintaining the normative functioning of natural systems across the life cycle is an important component of maintaining natural patterns of diversity or variation. A variety of elements are encompassed under the aegis of "natural systems." For example, landscape and habitat-forming processes contribute to the range of variation potentially expressed in the spawning and rearing life stages. Alterations to the hydrograph, for example, could substantially alter outmigration or spawn timing. Similarly, the effects of the biological community, such as predation, competition and nutrient availability have the potential to affect the range of diversity that is expressed within a population. Finally, changes to the system or environment across the salmonid life cycle that differentially affect subcomponents of the population can alter natural patterns of diversity. An obvious example of such a change is strong size-selective harvest; populations subject to such harvest have likely experienced a shift in phenotype. *Importantly, in each of these situations it is not only that change has occurred, but also that the change is selective. In other words, that change causes a shift, truncation, or other alteration to the normal variation of the population, rather than merely a decrease in overall population survival or abundance.*

Factor B.4.a. Change in natural processes or impacts. As with genetic measures, assessing change in natural processes or impacts with respect to diversity requires a case-by-case approach. For this reason, we developed a scoring system that requires a qualitative or quantitative assessment of the selectivity of relevant changes to the natural system for each population. Factors judged to have no likely selectivity receive a score of 0; those with low selectivity receive a score of 1; moderate selectivity has a score of 2; and high or severe selectivity has a score of 4. Scores for all relevant factors are added for an overall "integrity of natural systems" rating. Our complete technical description of viability criteria will describe the process of evaluating the selectivity of an impact more thoroughly. We present preliminary criteria for planners to be able to gauge the likely degree of selectivity in natural systems associated with several risk levels (Table 11).

Table 11. Preliminary criteria associating risk with selectivity scores, describing change in natural processes or impacts.

Factor/Metrics	Pop. Group	Risk Level: Very Low	Low	Moderate	High
Factor: Change in natural processes and impacts	A	0	1	2	3
	B	2	3	4	5
Metric: Cumulative selectivity score across all relevant impacts	C	1	2	3	4
	D	Core =0 Tribs =2	Core =0 or 1 Tribs =4	Core =1 or 2 Tribs =4	Core =2 or 3 Tribs =5

MPG and ESU Criteria Development

We are continuing to develop viability criteria at the MPG and ESU levels. Our preliminary guidelines, described in our original document, rely on the precedent set by other TRTs to propose that 1) the greater of two or one-half of the populations historically within the MPG should be at high viability, with remaining populations at least maintained; and 2) all major life history strategies present historically within each MPG should be present, for the MPG as a whole to be regarded as "at low risk." (See *Viability Criteria: Summary of Approach and Preliminary Results*, dated 8/05/04, at http://www.nwfsc.noaa.gov/trt/trt_columbia.htm for further discussion). More recently, we are proposing an additional guideline that considers the differences in intrinsic size between populations:

- *The populations at high viability within an MPG should include proportional representation from populations classified as Large or Intermediate (based on intrinsic potential).*

In other words, an MPG that includes two Large populations and four Basic populations should have at least one of the Large populations at a high level of viability to be considered at low risk.

Again, we are continuing to evaluate alternative scenarios to determine the sufficiency of these minimum criteria for Interior Columbia ESUs. Thus, these guidelines may be refined in response to new information, analyses or review. We present them at this early state for planners to gauge the magnitude and scope of likely necessary recovery effort.

Attachment A: Preliminary Population Assignment to Size and Structural Categories

We have preliminarily assigned populations to categories based on their size (Table A-1), for abundance and productivity criteria, and based on their structural features (Table A-2), in support of spatial structure and diversity criteria. Methods for assigning populations to size categories are further described in Attachment B. Because these assignments, particularly for structural categories, are preliminary, we welcome comments and suggestions, and intend to conduct a review of these assignments in the near future. We provide these preliminary assignments to better inform local and regional conservation planners about likely population-specific requirements for viability.

Table A-1. Preliminary assignment of populations to SIZE categories, for listed ESUs in the Interior Columbia Basin.

MPG	Size Category		
	Basic	Intermediate	Large
Upper Columbia Spring Chinook			
Cascade Slopes	Entiat R. Okanogan R.		Wenatchee R. Methow R.
Snake R. Spring/Summer Chinook			
Lower Snake	Asotin Cr.	Tucannon R.	
Grande Ronde/Imnaha	Lookinglass Cr. Wenaha R. Minam R. Big Sheep Cr.	Catherine Cr. Imnaha R.	Wallowa/Lostine R. Upper Grande Ronde R.
South Fork Salmon	Secesh R. East Fk. S. F. Salmon R. Little Salmon R.		S. Fk. Mainstem
Middle Fork Salmon	Lower Mainstem Sulphur Cr. Camas Cr. Loon Cr. Marsh Cr. Bear Valley Cr.	Big Cr. Upper Mainstem Chamberlain Cr.	
Upper Salmon	Yankee Fk. Valley Cr. North Fk. Salmon R. Panther Cr.	Upper Salmon R. Mainstem U. Salmon Lower Mainstem Pahsimeroi R.	Lemhi R.

MPG	Size Category		
	Basic	Intermediate	Large
Upper Columbia Steelhead			
Cascade Slopes	Entiat R.	Wenatchee R. Methow R. Okanogan R.	
Mid-Columbia Steelhead			
Eastern Slope Cascades Tributaries	Rock Creek	White Salmon R. Fifteenmile Cr. Deschutes – Westside tributaries Deschutes—Eastside tributaries	Klickitat R.
John Day		S. Fk. John Day R. Upper John Day R. Middle Fk. John Day R.	Lower John Day R. N. Fk. John Day R.
Yakima		Satus/Toppenish Cr.	Naches R. Upper Yakima R.
Umatilla/Walla Walla		Walla Walla R. Touchet R.	Umatilla R.
Snake R. Steelhead			
Lower Snake		Tucannon R. Asotin Cr.	
Grande Ronde		Joseph Cr. Lower Grande Ronde R. Wallowa R.	Upper Grande Ronde R.
Clearwater	Lolo Cr.	Lochsa R. South Fk. Clearwater R.	Selway R. Lower Clearwater R. N. Fk. Clearwater R.
Salmon	Secesh R. Chamberlain Cr. North Fk. Salmon R.	Little Salmon R. S. Fk. Salmon R. U. Middle Fk. Salmon R. Panther Cr. Lemhi R. Pahsimeroi R. East Fk. Salmon R. Upper Mainstem	Big Cr.
Imnaha		Imnaha R.	
Hells Canyon	Hells Canyon Tributaries		

Table A-2. Preliminary assignment of populations to STRUCTURAL categories for listed ESUs in the Interior Columbia Basin.

MPG	Structural Category A Small and/or Linear	B Dendritic, Multiple Spawning Aggregations	C Trellis-structured, Mainstem with Branches	D Core Area with Adjunct Tributaries
Upper Columbia Spring Chinook				
Cascade Slopes	Entiat R. Okanogan R.	Wenatchee R. Methow R.		
Snake R. Spring/Summer Chinook				
Lower Snake	Asotin Cr. Tucannon R.			
Grande Ronde/Imnaha	Lookinglass Cr. Wenaha R. Minam R. Wallowa/Lostine R. Big Sheep Cr. Imnaha R.	Catherine Cr. Upper Grande Ronde R.		
South Fork Salmon	Secesh R.	East Fk. S. F. Salmon R.	S. Fk. Mainstem	Little Salmon R.
Middle Fork Salmon	Lower Mainstem Sulphur Cr.	Big Cr. Camas Cr.	Upper Mainstem Loon Cr. Marsh Cr. Bear Valley Cr.	Chamberlain Cr.
Upper Salmon	Valley Cr. U. Salmon Mainstem	Lemhi R.	Panther Cr. Pahsimeroi R. Yankee Fk.	North Fk. Salmon R. U. Salmon Lower Mainstem
Upper Columbia Steelhead				
Cascade Slopes	Entiat R. Okanogan R.	Wenatchee R. Methow R.		
Mid-Columbia Steelhead				
Eastern Slope Cascades Tributaries	White Salmon R. Rock Creek	Klickitat R. Deschutes – Westside tributaries Deschutes—Eastside tributaries	Fifteenmile Cr.	
John Day		Lower John Day R. S. Fk. John Day R. Upper John Day R. Middle Fk. John Day R. N. Fk. John Day R.		
Yakima		Satus/Toppenish Cr. Naches R. Upper Yakima R.		
Umatilla/Walla Walla	Touchet R.	Umatilla R. Walla Walla R.		
Snake R. Steelhead				
Lower Snake	Tucannon R.			Asotin Cr.
Grande Ronde		Joseph Cr. Lower Grande Ronde R. Wallowa R. Upper Grande Ronde R.		

MPG	Structural Category			
	A Small and/or Linear	B Dendritic, Multiple Spawning Aggregations	C Trellis-structured, Mainstem with Branches	D Core Area with Adjunct Tributaries
Clearwater		Selway R. Lochsa R. South Fk. Clearwater R. Lower Clearwater R. N.Fk. Clearwater	Lolo Cr.	
Salmon		S. Fk. Salmon R. Big Cr. U. Middle Fk. Salmon R. Lemhi R. East Fk. Salmon R. Upper Mainstem	Secesh R. Pahsimeroi R.	Little Salmon R. Chamberlain Cr. Panther Cr. North Fk. Salmon R.
Imnaha		Imnaha R.		
Hells Canyon				Hells Canyon Tributaries

Attachment B: Categorizing Populations by Intrinsic or Historical Size

The intent of this analysis is to develop and apply an approach for characterizing the relative size and complexity of Interior Columbia Basin stream type chinook and steelhead populations based on available GIS data layers and empirically derived fish/habitat relationships. The results will be used by the Interior Columbia Technical Recovery Team to: 1) adapt viability curves (abundance/productivity criteria) to reflect population size, and; 2) contribute to the development of spatial structure/diversity criteria.

Background

One of the major tasks assigned to Technical Recovery Teams (TRTs) is the development of population level viability criteria for the specific Evolutionarily Significant Units (ESUs) within their assigned domain. The Interior Columbia River domain covers seven ESUs previously listed under the Endangered Species Act (ESA). The Interior Columbia Basin TRT has identified the basic population structure of these ESUs in a previous report. The tributary drainages used by populations within Interior Basin ESUs vary considerably in terms of size and complexity. Table B-1 summarizes the range in drainage area associated with Interior Basin ESU populations of stream type chinook and steelhead.

ESU	Extant Populations (#)	Basin Drainage Area	
		Smallest	Largest
Snake R. Spring/Summer Chinook	29	130	3,800
Upper Columbia Chinook	3	1,080	4,700
Snake R. Steelhead	22	625	6,800
Mid-Columbia Steelhead	16	600	9,600
Upper Columbia Steelhead	3 (+1?)	1,075	4,700

Examples of populations occupying smaller drainages include Asotin Creek and Sulphur Creek (Snake R. Steelhead and Spring/summer Chinook ESUs); Rock Creek and Fifteen Mile Creek (Middle Columbia Steelhead ESU) and the Entiat R. (Upper Columbia Steelhead and Spring Chinook ESUs). Populations using relatively large, complex tributaries include Upper John Day steelhead, Wenatchee and Methow R. steelhead and spring chinook, and Lemhi River steelhead and spring/summer chinook. This natural variation in size and complexity suggests that even historically, populations likely varied in their relative robustness, or resilience to perturbations.

The ICBTRT has adopted the following general guideline for defining population abundance criteria: *Abundance should be high enough that 1) in combination with intrinsic productivity, declines to critically low levels would be unlikely assuming recent historical patterns of environmental variability; 2) compensatory processes provide resilience to the effects of short term perturbations; and 3) subpopulation structure is maintained (e.g., multiple spawning tributaries, spawning patches, life history patterns).* Two other Interior Columbia ESUs (Snake River Fall chinook and Snake R. sockeye) have also been listed under the Endangered Species Act. Both of these ESUs are limited to single extant populations. Delisting criteria for these ESUs are also being developed consistent with the basic guidelines and principles described below.

The Interior Basin Technical Recovery Team is developing a set of generic viability curves as the basis for population specific abundance/productivity viability criteria. At least initially, those viability curves do not directly incorporate considerations for relative population size or complexity - although they do assume the possibility of a generic carrying capacity limit.

Methods
The following estimates of historical population size and spatial complexity are derived from the GIS modeling results developed for the Interior Columbia ESU Population Identification Report and for the FCRPS Biological Opinion Remand process (web address).

Steps

1. Criteria for identifying upper and lower bounds of spawning (with considerations for juvenile rearing) were developed based on data from historical spawning ground surveys, parr transects and literature reviews.
2. Reach scale (100 to 200 m) data sets relating parr densities to physical habitat characteristics were used to define relationships between relative measures of abundance and specific combinations of physical habitat measures (e.g., stream width, gradient and valley width) for each species.
3. GIS data layers were used to assign production potential ratings at the 200-meter reach scale within each the drainage structure assigned to each of the populations of chinook and steelhead, respectively.
4. The amount of habitat by ratings category was summed for each population. Weighted totals by population (and by sub-areas within populations) were also generated.

The following section includes additional information on the criteria used to develop estimates of historical Intrinsic Spawning potential for the tributary habitat associated with specific populations within Interior Columbia Basin stream type chinook and steelhead ESUs.

What is the minimum stream width associated with spring chinook spawning, with steelhead spawning?

We based these estimates on available redd count information for each species. For spring chinook, we used two data sets; 1) results from recent USFWS efforts in the Middle Fork Salmon R. and our regression model of stream width (low summer flows) and 2) index average stream widths for Grande Ronde spawning reaches to estimate the minimum stream width associated with spawning. For steelhead, we used John Day index area redd count data, *O. mykiss* presence/absence data from ODFW, and IDFG parr count data from the Salmon and Clearwater basins as our baseline data sets. These values were compared to the bankfull width estimations we generated using our low summer flow model (described below). In both the spring chinook and steelhead analyses, we took the 95th percentile low value for bankfull and wetted width to delineate our upstream extent.

Spring chinook:

1) Recent redd mapping by USFS (R. Thurow and coworkers). Overlaying the mapping of redd locations for the middle fork on the modeled stream width for our 200m reaches (wetted widths – see above) 4.5 m

2) Widths from Grande Ronde samples - (source: R. Carmichael, ODFW) minimum wetted widths associated with spawning were 3.3, 3.6 and 4.3 m. We also analyzed the current spawning of spring chinook in the Grande Ronde (as defined by ODFW GPS coordinates) and related these locations with our 200m reaches to compare modeled wetted width and spawning distribution.

Steelhead:

1) John Day basin redd count data is in GIS form at least at the scale of index reach – ok for rough approx. table/plot cumulative redds vs. GIS stream width, find lower cutoff – spawning. Only the index areas that corresponded with current upper extent spawning (as defined by ODFW) were used.

2) Clearwater and Salmon R. parr count data from IDFG (source: C. Petrosky, IDFG) was spatially conflated with our modeled 200m stream segments. Calculated bankfull widths were attached to IDFG survey locations in order to determine the density by width distributions.

3) *O. mykiss* presence/absence data from ODFW was also spatially joined to modeled reaches in order to analyze distribution by bankfull width.

For the purpose of this analysis, we are restricting spawning designation to stream width greater than 3.6 m wetted width for spring chinook and 3.8 m bankfull width for steelhead.

How many km of index type reach habitat are required to sustain 500 spawners? 250

Spawners?

Tributary habitats associated with specific Interior Columbia Basin stream type chinook and steelhead populations varied considerably in size and complexity (see above). Within population spatial structure is an important consideration in assessing risk levels relative to localized (watershed level) catastrophic events. In addition, the presence of multiple, relatively discrete spawning areas within a population can increase the potential for development and expression of within population phenotypic and genotypic diversity. The relative size of discrete spawning areas within the tributary habitat used by a particular population is an important consideration. The ICTRT developed the following estimate of the minimum amount of tributary spawning habitat needed to support 500 spawners as a metric for use in characterizing within population spatial structure. Populations that include multiple, relatively discrete areas each capable of sustaining 500 or more spawners are hypothesized to be at less overall risk than populations with one such spawning area.

Spring chinook: At an average of 20.7 redds per km and assuming 2 spawners/redd, 12 km of index reach type habitat would be required to sustain 500 spawners at relatively high spawning densities, 6 km to support 250 spawners.

Steelhead: Given an average of 8.3 redds per km and 2 spawners per redd, 30 km of index reach type habitat would be required to support 500 steelhead spawners at relatively high spawning densities, 15 km to support 250 spawners at relatively high spawning densities

How do these values compare to the amount of habitat available within populations?

Populations vary greatly in terms of the physical structure, spatial distribution of spawning/rearing potential. How do the minimum patch size requirements described above relate to potential measures of spawning/rearing area within populations?

Recent efforts to calculate historic intrinsic potential can be used as the basis for quantifying historical habitat. Those estimates are based upon rearing capacities or preference. Assuming that spawning is also associated with the stream features (widths, gradients) driving the rearing capacity estimates, that data set can be used to generally quantify the amount and distribution of historical spawning habitat. Two important caveats - as described above, juvenile rearing can occur under a broader range of habitat conditions than spawning. As a first cut, the estimated total available habitat should be screened by stream width - restricting the amount of habitat to the range of widths associated with spawning.

HUC-5s and HUC-6s are two levels of watershed designation that are readily available in GIS format for all basins. These units of habitat generally correspond to potential patches of salmon habitat - e.g., separate tributary branches. Put in formal definition. Under this approach, minimum patch size has been indexed to measures of spawning habitat - the minimum number of stream kilometers required to support a particular number of spawners (i.e., 250 or 500). The amount of rearing habitat associated with that increment of spawning habitat may be higher - reflecting the distribution of juveniles originating from the spawning reach into smaller side tributaries, downstream rearing areas, etc.

How many stream kilometers of spawning habitat are in HUC-5 watersheds for spring chinook? For steelhead?

Spring chinook
The total amount of spawning habitat (H/M rating width greater than 3m) was summed over all reaches within each HUC-5 for chinook populations. H/M stream kilometers were also totaled at the population level. The resulting totals were compiled (covering both the UC and Snake River spring chinook ESUs).

The median length of stream kilometers of high / medium rated spawning habitat was 25 km, ranging from 0 to approximately 100 km (within a Snake R. Little Salmon R. HUC-5). 90% of the HUC-5s within population boundaries contained 10 or more kilometers of high/med spawning habitat.

Steelhead
The median number of spawning habitat (high/medium intrinsic potential rating) per HUC-5 was 75 km for steelhead populations compiled across all three Interior Columbia listed ESUs. 90% of the HUC-5s contained between 18 and 172 km of high/medium rated habitat.

Weighted spawning kilometers within a population area will be the metric used for categorizing the relative size and complexity of populations within Interior Basin ESUs.

Each of the metrics described above provides useful insights regarding potential population size and complexity. Measures of rearing capacity can be used in assessments of the potential effects of habitat changes (e.g., historical to current) on stock production and abundance. An estimate of potential stream kilometers of spawning area is particularly relevant measure for use in expressing the size of specific populations relative to abundance/productivity criteria. A strong tendency for returning spawners to home back to natal spawning areas is a general characteristic of chinook and steelhead. The predominant life history patterns for both of these species involve a year or more freshwater rearing, generally in the natal tributary. Returns to particular spawning reaches are therefore largely dependent upon the production from the previous generation of spawning in that same reach. As a result, the availability of suitable quantities of high quality rearing habitat also affects production and therefore average abundance associated with a particular spawning area.

Stream Type Chinook
Estimates of intrinsic potential spawning habitat were generated for 35 populations of Interior Basin stream type chinook from the Upper Columbia and Snake R. ESUs. Stream reaches were weighted by juvenile rearing potential and summed within

population units. Populations were tabulated in order of estimated total weighted stream kilometers of rearing habitat. Three general groupings of populations were identified based upon relatively large increases in weighted spawning habitat between adjacent pairs of populations in the ordered list, with consideration for the number of major watersheds in each population (indexed as the number of HUC-5 watersheds containing 10 or more km of weighted spawning habitat). The resulting groupings for spring/summer chinook are illustrated in Figure 1.

A grouping of 20 relatively small and spatially simple Spring/summer Chinook populations was defined based on a moderate gap in population spawning kilometers (13% difference) between the estimates for the Bear Valley/Elk Creek and Chamberlain Creek populations. Using the same metrics, this group of 20 populations could be broken down further based on a disproportionate increase in spawning kilometers between the Lower Mainstem Middle Fork and Camas populations. The break at 20 populations was set after considering the potential effect of temperature limitations and the relative number of HUC-5 watersheds within each population.

A group of 5 relatively large and complex populations was defined by an 11% gap in the cumulative size distribution between the estimate for the Pahsimeroi R. and the Lostine R. populations. A grouping of 10 populations of intermediate size and complexity was defined by the breakpoints separating the groups of smaller and larger populations. The proportional range in population size within each of the three groupings was relatively consistent - with populations varying in size by roughly a factor of 2 (Table 2).

Figure B-1 Interior Columbia Basin Stream Type chinook populations. Ordered by intrinsic potential (km of weighted spawning/rearing habitat. Bar patterns indicated groupings (Basic, Intermediate, Large).

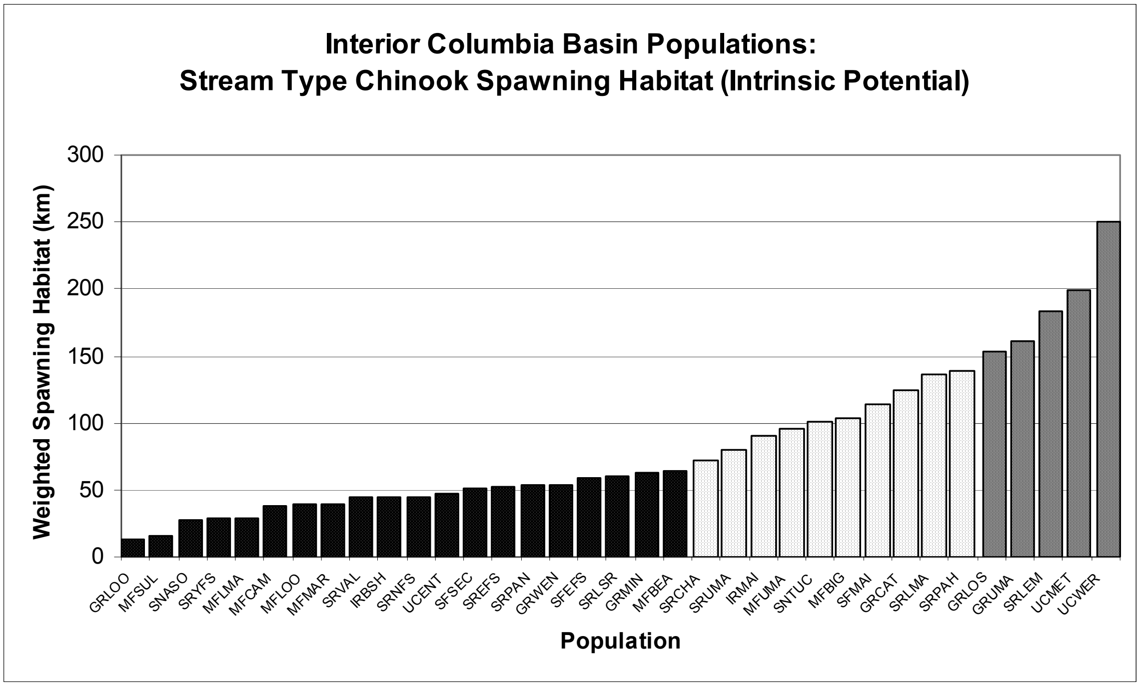


Table B-2. STREAM TYPE CHINOOK. *Summary statistics for population size/complexity categories. (Basic, Intermediate and Large*)

Stream Type Chinook	Tributary Habitat Capacity/Complexity Categories		
	Basic	Intermediate	Large
No. of Populations	20	10	5
Spawning Kilometers			
Median	45	103	184
Range	13 - 64	72 - 139	154 - 250
# per Population:			
HUC-5 watersheds			
Median	1.5	5	5
Range	1 - 4	2 - 12	4 - 10

Steelhead

Estimates of the amount (in kilometers) of historical spawning habitat were generated for 47 populations of steelhead from three ESUs - Upper Columbia (4), Middle Columbia (17) and Snake R. (26). For each population, accessible tributary habitats were rated for spawning potential using the standard set of rules described above. The estimated amount of total spawning habitat was summed for each population. A second summation was also calculated, with each stream segment being weighted according to its relative potential to support juvenile rearing. Steelhead juveniles typically rear for 2-3 years in freshwater before migrating to the ocean. Given the strong homing propensity of returning steelhead spawners, the relative rates of return to a particular spawning area are likely to be significantly influenced by juvenile survivals.

Steelhead tributary population areas were generally larger than the areas associated with spring/summer chinook, reflecting the wider range of spawning conditions characteristic of steelhead. In addition, less information is available for steelhead to identify breaks between population areas, largely due to the fact that they spawn on or shortly after the spring freshet and that the adults do not die immediately after spawning. Three groupings of steelhead populations were identified based on 'breaks' in the cumulative size distribution across the forty-seven populations analyzed (Figure 2; Table 4).

A grouping of 6 relatively small populations with relatively simple spatial structure was defined by a break in the cumulative size distribution between 181 sq. km (North Fork Salmon R.) and 250 sq. km (Little White Salmon population -extirpated). We considered an alternative break point between 284 (Joseph Cr.) and 354 (Pahsimeroi R.). We decided against that alterative because the proportional increase at that potential breakpoint was less than at the selected tributary size break, and use of the larger size break would have included three relatively complex populations in the Basic size category.

A grouping of relatively large, spatially complex populations was defined based upon a relatively large gap in population size between 662 km (Methow R.) and 735 km (Big Creek). The 11 populations in this grouping are characterized by relatively high spatial complexity - 7 out of the 11 contain 10 or more HUC-5 watersheds with substantial spawning potential.

The remaining populations were classified into as Intermediate in size and complexity - 23 out of the 30 populations in this category had 5 or more HUC-5 watersheds with the potential to support significant numbers of spawning steelhead.

The population groupings were based on physical measures of habitat - stream gradient and width were the determining factors for steelhead spawning potential. Other factors can substantially affect the relative productivity of a particular reach or watershed including temperature conditions and aquatic productivity. We do not have a comprehensive data set representing historical (pre 1850) stream temperatures for Interior Columbia tributaries. We used regression models based on available stream temperature-elevation data to characterize reach specific temperature regimes. Those projections reflect the factors driving stream temperatures during the periods of observation and are not necessarily representative of historical conditions. However temperature mapping based on those relationships can be used to identify populations that are subject to relatively high stream temperatures during key rearing (and spawning periods). The intrinsic spawning or rearing potential estimates for populations exhibiting relatively high potential temperature impacts should be validated using alternative information wherever possible.

Incorporating a summer temperature maximum constraint (weekly maximum less than 22 deg. C) substantially reduced the estimated amount of spawning habitat for many Mid-Columbia ESU and lower Snake River steelhead populations. In most cases the reductions in spawning area were associated with lower Mainstem small tributaries.

Figure B-2 Interior Columbia Basin Steelhead populations. Ordered by intrinsic potential (km of weighted spawning/rearing habitat). Bar patterns indicated groupings (Basic, Intermediate, Large)

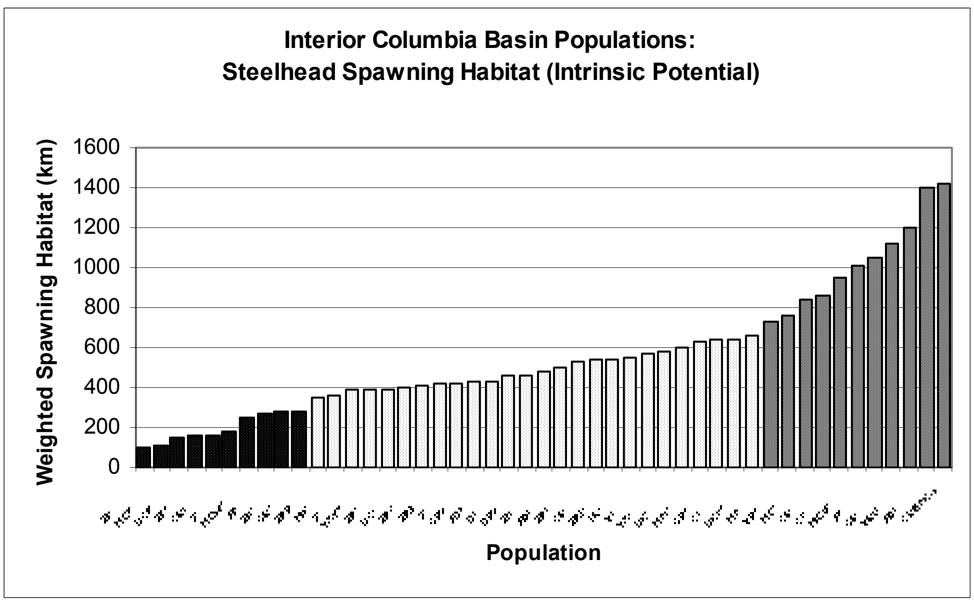


Table B-4. Steelhead. Summary statistics for population size categories. (Basic, Intermediate and Large)

Steelhead	Tributary Habitat Capacity/Complexity Categories		
	Basic	Intermediate	Large
No. of Populations	6	30	11
Spawning Kilometers			
Median	154	443	1013
Range	103 - 181	250 - 662	735 – 1422
# per Population:			
HUC-5 watersheds			
Median	1	5	11
Range	1 - 3	2 - 9	4 – 17

Attachment C: General Approach for Defining Major Spawning Areas within Populations for the Interior Columbia Basin ESUs

Spatial structure varies greatly both within and among ESA-defined Chinook salmon and steelhead populations. Both temporal and geographic variations exist within occupied systems, resulting in a wide array of spawning configurations. These structural differences have implications for a population's intrinsic viability, and by analyzing spatial composition, planners have an opportunity to evaluate how sustainable production can be achieved.

In our approach to describing spatial structure, we designated the basic building block for a salmonid population as a *branch.* In our definition, a branch component can be any reach organization containing suitable spawning habitat within a subwatershed. The quantity and interrelatedness of branches within a watershed contribute to a population's risk level in regard to sustainable production.

Additionally, the organizational variation and quantity of branch habitat within targeted populations determine the distribution of major (MSA) and minor (mSA) spawning aggregations. We developed a rule set (Figure A-2) in order to clearly define and delineate MSA and mSA structures. As with branches, to manage for sustainable productivity it is crucial to understand the geographic composition of spawning aggregations and their associated implications.

Moving Window Methodology

Branch development

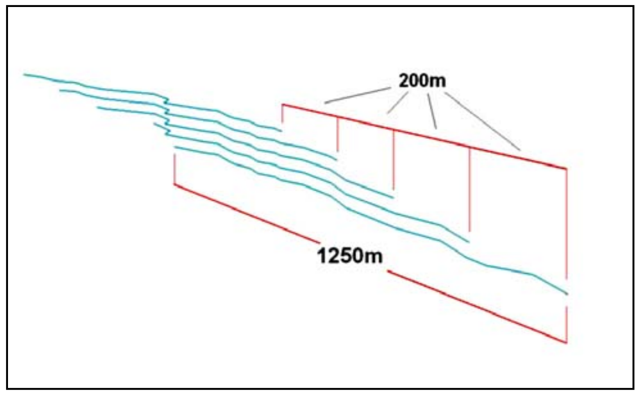
Using GIS techniques, our team developed a methodology for defining and displaying branches. We applied a *moving window* design for evaluating habitat within steelhead and Chinook salmon ESA reaches. Our moving window spatial parameters were inherited from minimum branch size definitions, which are equivalent to the amount of habitat required to sustain 50 spawners (approximately 1.25 km for spring/summer chinook, and 3.0 km for steelhead). These stream distances, then, became the calculated lengths for our moving window spatial theme.

Using linear referencing techniques, we compiled tabular descriptions for the moving window features (Figure A-1). Each window was addressed with "from" and "to" and feature code attributes. The addresses were offset by 200-m increments, so that for each reach, the window began at 0 m and stopped at 3,000 m (steelhead) or 1,250 m (Chinook salmon), then continued upstream at 200 m, ending at 3,200m (steelhead) or 1,450 m (Chinook salmon). This pattern continued until the headwaters of the hydrologic feature were reached. The result was a set of overlapping segments representing a *moving window* spatial theme (Figure A-1b).

Table C-1. Address table for linear referencing of "moving windows."

Feature id		Branching parameters				
Llid	Stream name	From Chinook (m)	To Chinook (m)		From Steelhead (m)	To Steelhead (m)
1190674487624	Pettijohn Creek	0	1,250		0	3,000
1190674487624	Pettijohn Creek	200	1,450		200	3,200
1190674487624	Pettijohn Creek	400	1,650		400	3,400
1190674487624	Pettijohn Creek	600	1,850		600	3,600
1190674487624	Pettijohn Creek	800	2,050		800	3,800

Figure A-1b. **Example of spring Chinook salmon "moving window" linear referencing.**



The second step was to identify each window's intrinsic values and calculate an average rating. The mean intrinsic calculation was our fundamental metric for determining which windows qualified for *branch* status. Because our definition stated that branches could only contain "high" or "moderate" values (hence, the most productive habitat), it was necessary to determine the average intrinsic rating and attribute it to individual windows. To do this we intersected our moving window features with those from our intrinsic potential analysis, and then summarized the mean rating for the segments underlying each window. From this analysis, we queried where the mean intrinsic value was at least equal to "moderate" and saved it as a new spatial theme. In this way, our moving windows are represented as a spatially derived moving average of intrinsic habitat quality.

MSA development

Once our branched distribution was spatially defined, we delineated MSA and mSA subwatersheds. Major spawning aggregations were defined as a system of one or more branches that contain sufficient habitat to support 500 spawners. For spring and summer Chinook salmon, this value was 100,000 m^2; for steelhead it was 250,000 m^2. We generated aggregation values by using hydrology tools within the GIS. These tools are most commonly used to calculate hydrographic features, such as flow direction and accumulation, and watershed delineation.

In our evaluation, we employed flow accumulation functions (using the weighted area calculations from the intrinsic analysis) to calculate potential salmonid production. Starting from the highest elevation within a hydrologic basin, the aggregation continued downstream, accumulating branch habitat until the watershed outlet was reached. This technique produced a hydrologically accumulated grid, which was weighted by the quantity of moderate and high intrinsic habitat within our previously defined branches. Using spatial analysis, we then subtracted the topographically derived (unweighted) flow accumulation from the intrinsically weighted accumulation grid. These results were then divided by 250,000 (for steelhead) or 100,000 (for Chinook salmon). The values in the resulting grid illustrated where the minimum habitat criteria were met for MSAs, so that each increasing whole number identified a new potential MSA (dependent upon other criteria within the rule set). With both branches, and MSA minimums defined, the MSA rule set was applied in order to define individual MSA (or mSA) subbasins.

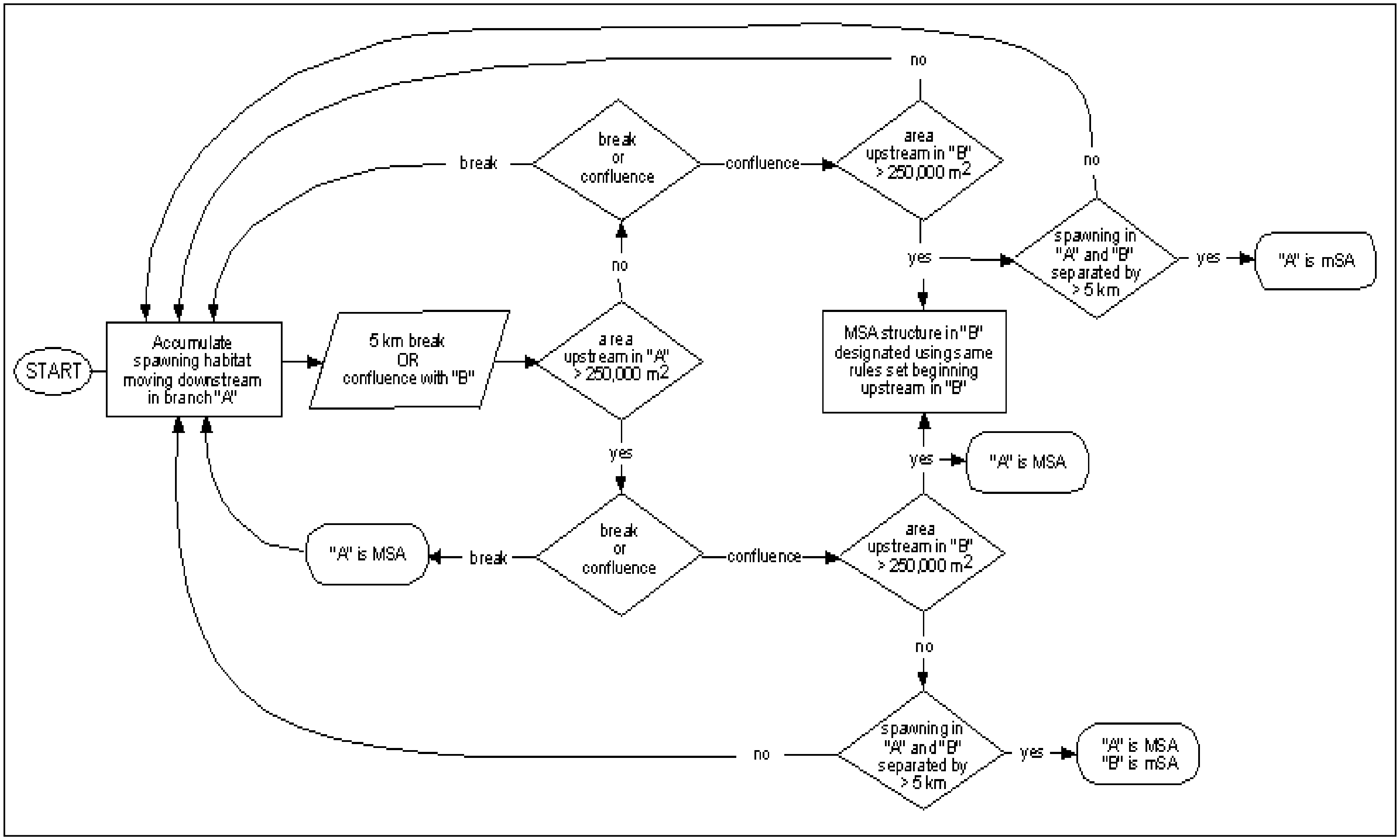
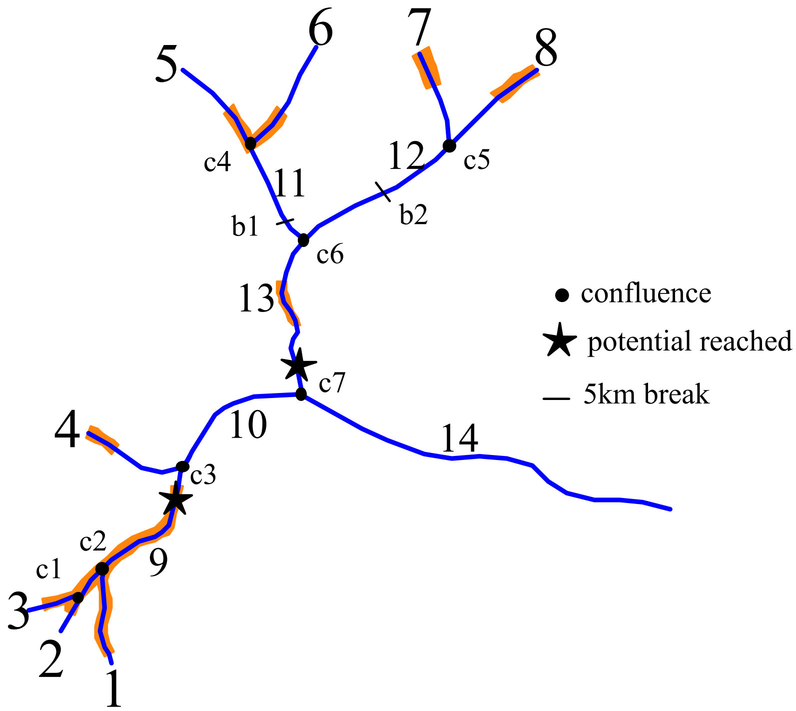


Figure C-2. Decision tree defining within-population major and minor spawning areas (summer steelhead).



Stream diagram to illustrate decision making process for MSA/mSA designation.

Arabic numbers 1-8 indicates a branch and possible start point. Higher order streams 9-14 are also labeled using arabic numerals. Each of seven confluences are marked with a black circle and labeled numerically (c1-c7). Five kilometer breaks in spawning habitat are indicated by a dash across the stream and labeled b1 and b2. Stars are the point at which the minimum potential spawning area to achieve MSA status has been reached.

Figure C-3. Example of applying an MSA decision flow chart to define spawning aggregations within a hypothetical population.

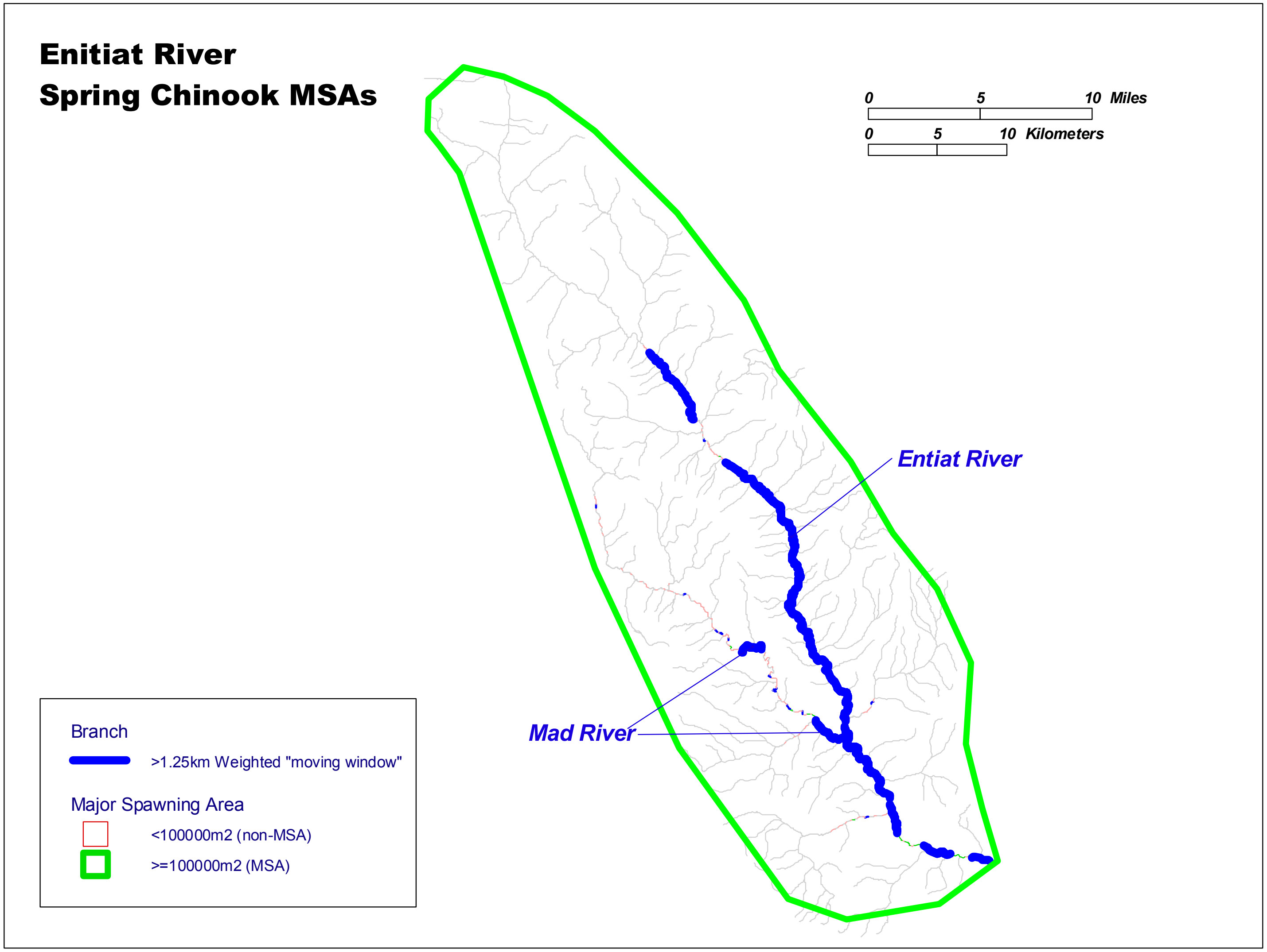


Figure C-4. Spring Chinook salmon basic size, simple linear pattern (category A).

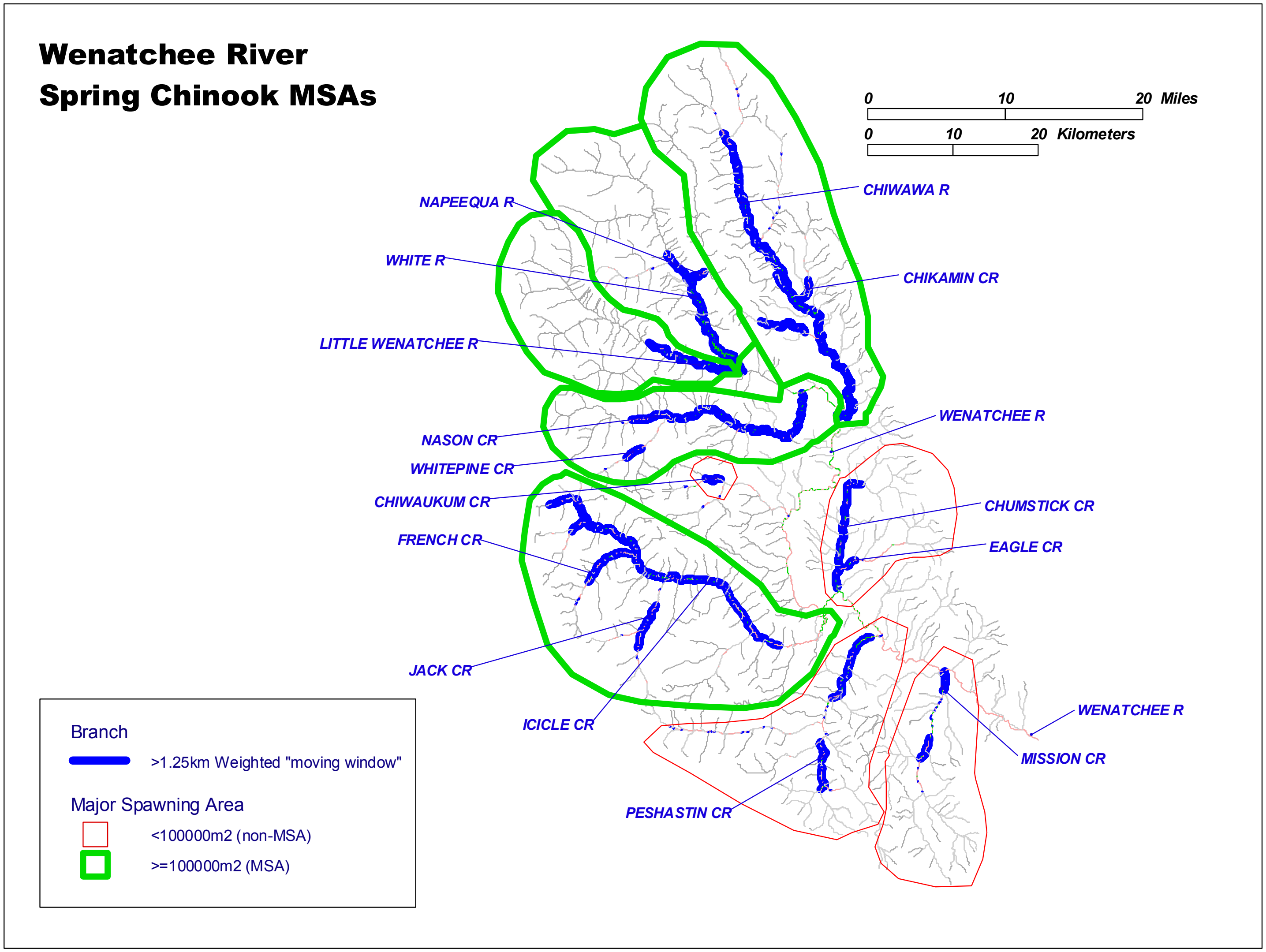


Figure C-5. Example of spring Chinook salmon large-size category, dendritic pattern (category B).

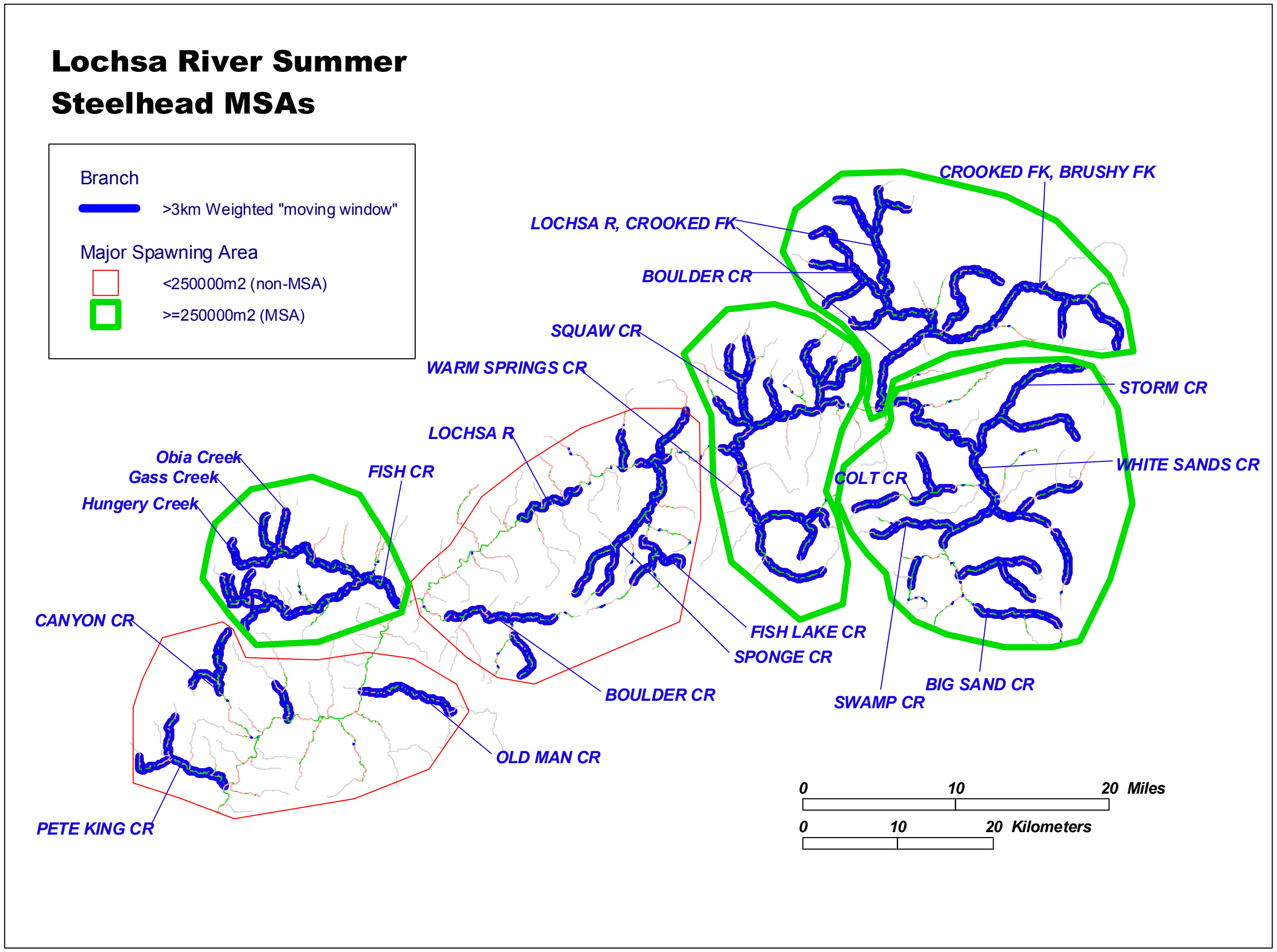


Figure C-6. Example of steelhead intermediate size group, trellis pattern (category D).

Attachment D: Habitat Diversity Index

We generated a habitat diversity index that can be calculated based on current or assumed historical distribution. This index is intended as a consistent comparison of the potential for a population to express phenotypic (life history, morphological and behavioral) diversity. It includes several factors thought to contribute to population-level diversity:

- range of stream widths within the population
- range of elevation used by spawners within the population
- number of branches within the population (described by Shreve stream order)
- an index of the amount of habitat available in wide valleys
- an index of the proportion of total precipitation that falls as snow (as a surrogate for hydrograph)
- number of ecoregions, and distribution of spawning across those ecoregions

We are currently working to improve and assess this index. We present these values as an aid to regional and local conservation planners so they can gauge the relative current diversity potential within their population. We intend to provide historical HDI values in the near future.

Table D-1. Habitat Diversity Index values for stream-type chinook populations in the Interior Columbia Basin based on current distribution. Components of the diversity index include stream width, elevation, branching, valley width, an index of snowfall to total precipitation, and an index of ecoregional diversity. A higher score indicates greater diversity potential.

	Standardized Diversity Index Components						Habitat Diversity Index (Three Alternative Calculations)		
Population	Current width range	Current elevation range	Current Shreve order/ # of branches	Valley Width Index	Snow Metric	Standardized Ecoregion Score	Ecoregion Score	Complete HDI	Reduced HDI (w/o ecoregion)
Asotin R.	0.00	0.15	0.00	0.31	0.17	0.30	4	0.93	0.63
Tucannon R.	0.16	0.35	0.00	0.19	0.33	0.50	6	1.53	1.03
Wenaha R.	0.19	0.24	0.16	0.63	0.33	0.00	1	1.55	1.55
Wallowa/Lostine R.	0.19	0.36	0.16	0.19	0.58	0.50	6	1.98	1.48
Lookinglass Creek	0.05	0.08	0.04	0.56	0.33	0.30	4	1.37	1.07
Minam R.	0.13	0.19	0.04	0.13	0.33	0.40	5	1.22	0.82

	Standardized Diversity Index Components						Habitat Diversity Index (Three Alternative Calculations)		
Population	Current width range	Current elevation range	Current Shreve order/ # of branches	Valley Width Index	Snow Metric	Standardized Ecoregion Score	Ecoregion Score	Complete HDI	Reduced HDI (w/o ecoregion)
Catherine Creek	0.09	0.27	0.08	0.25	0.67	0.50	6	1.86	1.36
Upper Grande Ronde R.	0.12	0.18	0.16	0.19	0.42	0.10	2	1.17	1.07
Imnaha R.	0.27	0.76	0.00	1.00	0.00	0.50	6	2.53	2.03
Big Sheep Creek	0.05	0.26	0.04	0.25	0.17	0.50	6	1.27	0.77
Little Salmon R.	1.00	0.95	0.44	0.19	0.75	1.00	11	4.33	3.33
South Fork Salmon R.	0.96	1.00	1.00	0.00	0.75	0.50	6	4.21	3.71
Secesh R.	0.20	0.69	0.24	0.19	0.42	0.30	4	2.04	1.74
E Fk S Fk Salmon R.	0.24	0.56	0.56	0.88	0.58	0.30	4	3.12	2.82
Chamberlain Creek	0.88	0.88	0.44	0.56	0.67	0.40	5	3.82	3.42
Big Creek	0.83	0.69	0.36	0.19	0.50	0.40	5	2.97	2.57
Lower Middle Fork Salmon	0.41	0.09	0.08	0.19	0.08	0.30	4	1.15	0.85
Camas Creek	0.21	0.91	0.20	0.25	0.67	0.30	4	2.53	2.23
Loon Creek	0.19	0.66	0.20	0.63	0.58	0.10	2	2.36	2.26
Upper Middle Fork Salmon	0.27	0.72	0.44	0.13	0.50	0.00	1	2.06	2.06
Sulphur Creek	0.09	0.34	0.12	0.25	0.42	0.00	1	1.21	1.21
Bear Valley Creek	0.18	0.19	0.60	0.31	0.42	0.00	1	1.70	1.70
Marsh Creek	0.14	0.26	0.28	0.25	0.50	0.30	4	1.73	1.43
Panther Creek (Historic)	0.20	0.55	0.04	0.25	0.75				1.78

	Standardized Diversity Index Components						Habitat Diversity Index (Three Alternative Calculations)		
Population	Current width range	Current elevation range	Current Shreve order/ # of branches	Valley Width Index	Snow Metric	Standardized Ecoregion Score	Ecoregion Score	Complete HDI	Reduced HDI (w/o ecoregion)
N Fk Salmon R.	0.63	0.70	0.24	0.19	0.92	0.50	6	3.17	2.67
Lemhi R.	0.27	0.54	0.20	0.13	0.67	0.50	6	2.31	1.81
Lower Salmon R.	0.54	0.55	0.64	0.31	1.00	0.60	7	3.65	3.05
Pahsimeroi R.	0.39	0.00	0.08	0.50	0.08	0.00	1	1.05	1.05
E Fk Salmon R.	0.34	0.43	0.40	0.13	0.58	0.30	4	2.18	1.88
Yankee Fork	0.15	0.44	0.48	0.88	0.67	0.00	1	2.61	2.61
Valley Creek	0.14	0.11	0.52	0.88	0.58	0.40	5	2.63	2.23
Upper Salmon R.	0.22	0.41	0.68	0.19	0.58	0.40	5	2.48	2.08
Wenatchee R.	0.63	0.34	0.36	0.25	0.50	0.40	5	2.47	2.07
Entiat R.	0.24	0.05	0.04	0.25	0.00	0.00	1	0.58	0.58
Methow R.	0.74	0.44	0.36	0.31	0.75	0.50	6	3.10	2.60

Table D-2. Habitat Diversity Index values for steelhead populations in the Interior Columbia Basin based on current distribution. Components of the diversity index include stream width, elevation, branching, valley width, an index of snowfall to total precipitation, and an index of ecoregional diversity.

	Standardized Diversity Index Components						Habitat Diversity Indices		
Population	Current width range	Current elevation range	Current Shreve order/ # of branches	Valley Width Index	Snow Metric	Ecoregion Score	Ecoregion Index Only	Complete HDI	Reduced HDI (w/o ecoregion)
White Salmon R. (His	0.42	0.05	0.02	0.38	0.08	0.33	4	1.28	0.95
Klickitat R.	0.64	0.37	0.04	0.38	0.31	0.42	5	2.16	1.74

	Standardized Diversity Index Components						Habitat Diversity Indices		
Population	Current width range	Current elevation range	Current Shreve order/ # of branches	Valley Width Index	Snow Metric	Ecoregion Score	Ecoregion Index Only	Complete HDI	Reduced HDI (w/o ecoregion)
Fifteen Mile Creek (win	0.20	0.53	0.08	0.29	0.15	0.67	8	1.91	1.25
Deschutes R., eastside	0.92	0.59	0.31	0.29	0.08	0.67	8	2.85	2.18
Deschutes R., Westside	0.87	0.42	0.07	0.38	0.38	0.75	9	2.87	2.12
Rock Creek	0.15	0.29	0.02	0.29	0.08	0.58	7	1.40	0.81
John Day R. lower ma	0.71	0.82	0.80	0.57	0.38	0.75	9	4.04	3.29
North Fork John Day R.	0.34	0.70	1.00	0.29	0.46	0.83	10	3.62	2.79
Middle Fork John Day R.	0.24	0.57	0.37	0.19	0.62	0.58	7	2.56	1.98
South Fork John Day R.	0.23	0.50	0.16	0.57	0.38	0.75	9	2.59	1.84
John Day upper mainstem	0.29	0.62	0.40	0.67	0.62	0.67	8	3.26	2.60
Middle Fork Salmon R.	0.26	0.54	0.23	0.29	0.15	0.67	8	2.14	1.47
Walla Walla R.	0.34	0.50	0.11	0.38	0.31	0.83	10	2.46	1.63
Touchet R.	0.29	0.42	0.06	0.29	0.31	0.50	6	1.87	1.37
Toppenish and Satus Cr.	0.23	0.38	0.08	0.38	0.31	0.42	5	1.79	1.38
Naches R.	0.73	0.41	0.12	0.29	0.46	0.75	9	2.75	2.00
Yakima R. upper main	0.91	0.30	0.07	0.48	0.54	0.67	8	2.96	2.29
Tucannon R.	0.77	0.44	0.02	0.48	0.31	0.67	8	2.68	2.02
Asotin Creek	0.20	0.41	0.07	0.29	0.08	0.42	5	1.46	1.05
Clearwater lower mainstem	0.32	0.68	0.22	0.38	0.38	1.00	12	2.99	1.99
North Fork Clearwater	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00	0.00

	Standardized Diversity Index Components						Habitat Diversity Indices		
Population	Current width range	Current elevation range	Current Shreve order/ # of branches	Valley Width Index	Snow Metric	Ecoregion Score	Ecoregion Index Only	Complete HDI	Reduced HDI (w/o ecoregion)
Lolo Creek	0.26	0.58	0.03	0.48	0.46	0.50	6	2.31	1.81
Lochsa R.	0.41	0.77	0.25	0.19	0.62	0.58	7	2.83	2.24
Selway River	0.51	0.85	0.44	0.29	0.85	0.58	7	3.51	2.93
South Fork Clearwater R	0.37	0.67	0.25	0.67	0.69	0.08	1	2.73	2.65
Grande Ronde lower mainstem	0.55	0.60	0.31	0.57	0.31	0.42	5	2.76	2.34
Joseph Creek	0.20	0.53	0.26	0.38	0.08	0.50	6	1.94	1.44
Wallowa R.	0.25	0.46	0.17	0.29	0.69	0.75	9	2.61	1.86
Grande Ronde Upper Main	0.56	0.55	0.51	0.29	0.46	0.75	9	3.12	2.37
Little Salmon and Rapid	1.00	1.00	0.24	0.43	0.69	0.83	10	4.19	3.36
Chamberlain Creek	0.21	0.85	0.31	0.38	0.77	0.50	6	3.02	2.52
Secesh R.	0.26	0.57	0.27	0.57	0.46	0.33	4	2.46	2.13
South Fork Salmon R.	0.47	0.88	0.06	0.48	0.69	0.33	4	2.91	2.58
Panther Creek	0.26	0.81	0.09	0.29	0.85	0.50	6	2.79	2.29
Big, Camas, and Loon Cr	0.52	0.81	0.22	0.38	0.77	0.33	4	3.04	2.70
Middle Fork Salmon R.	0.47	0.65	0.32	1.00	0.62	0.33	4	3.39	3.06
North Fork Salmon R.	0.64	0.70	0.08	0.29	1.00	0.67	8	3.37	2.70
Lemhi R.	0.31	0.54	0.06	0.67	0.62	0.58	7	2.76	2.18
Pahsimeroi R.	0.47	0.33	0.02	0.29	0.62	0.33	4	2.05	1.72
East Fork Salmon R.	0.28	0.47	0.07	0.38	0.77	0.42	5	2.39	1.97

	Standardized Diversity Index Components						Habitat Diversity Indices		
Population	Current width range	Current elevation range	Current Shreve order/ # of branches	Valley Width Index	Snow Metric	Ecoregion Score	Ecoregion Index Only	Complete HDI	Reduced HDI (w/o ecoregion)
Salmon R. upper main	0.26	0.50	0.32	0.38	0.77	0.42	5	2.65	2.23
Snake R. Hells Canyon	0.11	0.44	0.12	0.48	0.38	0.08	1	1.62	1.53
Imnaha R.	0.21	0.76	0.33	0.67	0.54	0.50	6	3.00	2.50
Wenatchee R.	0.86	0.41	0.07	0.62	0.38	0.42	5	2.76	2.34
Entiat R.	0.36	0.25	0.02	0.57	0.08	0.17	2	1.44	1.28
Methow R.	0.76	0.37	0.06	0.62	0.77	0.42	5	3.00	2.58
Okanogan R.	0.01	0.08	0.01	0.48	0.08	0.08	1	0.74	0.65

Attachment E: Population and MPG Characteristics

A summary of population characteristics organized by MPGs within specific ESUs is provided in the following tables. Information on a set of key indicators of diversity and spatial complexity at the population level are summarized for each grouping.

Dominant ecoregions - the tributary reaches associated with individual populations can fall within different major ecoregions. Ecoregions represent provincial level differences in vegetation, lithography and elevation.

Life History types (Adults). Differences in adult return timing are generally related to flow and temperature conditions conducive to spawning and incubation requirements. Although multiple adult timing patterns are present within some populations, between population diversity is an important consideration.

Spawning Habitat Quantity: (expressed as kilometers and # of HUC 5 watersheds). Some MPGs historically included a significant proportion of large and complex populations. MPG viability criteria highlight the need to consider these populations in recovery scenarios.

Valley/Stream width ratio: Tributary reaches within unconfined wide valleys provide relatively stable, complex habitats for juvenile rearing (summer and winter phases). The presence of a significant amount of such habitat within a population provides for reduced risks of localized loss and promotes the expression of juvenile life history diversity.

Diversity Index (within population): Some populations have higher intrinsic capacity to support the expression of diversity than others. The Diversity Index included in the MPG summary is described in Attachment D.

Adaptation to temperature/precipitation levels can be an important component of diversity within ESUs. Elevation is generally considered a good surrogate for precipitation and temperature. Meeting the MPG population criteria described above would maintain viable populations across the historical range in elevation associated with each ESU (see attached figures).

Snake R. Spring/Summer Chinook ESU:

Table E-1: Summary of population characteristics by Major Population Grouping.

Snake River Spring/Summer Chinook ESU

Major Grouping	Populations	Dominant Ecoregion	Life History Types (Adults)	Spawning (complex***, length, HUC5s)	Valley/stream width ratio	Current Diversity Index*
Lower Snake Mainstem Tribs	Tucannon R.	Columbia Plateau	Spring	***Inter. (A, 101.5, 2)***	High	1.53
	Asotin R.	Columbia Plateau	Spring	Basic (A, 27.0, 1)	Med	0.93
Grande Ronde/Imnaha	Upper Grande Ronde	Blue Mountains	Spring	**Large (B, 160.5, 4)**	Med	1.17
	Wallowa/Lostine R.	Blue Mountains	Spring	**Large (B, 153, 5)**	Med	1.98
	Imnaha River	Blue Mountains	Spring/Sum	***Inter. (A, 90.2, 4)***	Med	2.53
	Catherine Creek	Blue Mountains	Spring	***Inter. (B, 125, 4)***	High	1.86
	Minam R.	Blue Mountains	Spring	Basic (A, 62.4, 1)	Med	1.22
	Wenaha R.	Blue Mountains	Spring	Basic (A, 54, 1)	Low	1.55
	Big Sheep Creek	Idaho Batholith	Spring	Basic (A, 44.3, 2)	Med	1.27
	Lookingglass Cr. **	Blue Mountains	Spring	Basic (A, 13.2, 1)	Med	1.37
South Fork Salmon River	So. Fk. Salmon	Idaho Batholith	Summer	***Inter. (C, 114.2, 6)***	Low	4.21
	Secesh R.	Idaho Batholith	Summer	Basic (D, 60.8, 4)	Med	4.33
	Little Salmon/tribs	Blue Mountains	Spring & Sum	Basic (B, 58.8, 3)	Low	3.12
	East Fk So. Fk Salmon	Idaho Batholith	Summer	Basic (A, 51.1, 1)	Med	2.04
Middle Fork Salmon River	Upper Middle Tribs	Idaho Batholith	Spring	***Inter. (C, 95.5, 6)***	Low	2.06
	Chamberlain Cr./tribs	Idaho Batholith	Spring	***Inter. (D, 71.8, 6)***	Low	3.82
	Big Cr.	Idaho Batholith	Spring & Sum	***Inter. (B, 103.9, 8)***	Low	2.97
	Bear Valley/Elk Cr.	Idaho Batholith	Spring	Basic (C, 63.6, 2)	High	1.70
	Marsh Cr.	Idaho Batholith	Spring	Basic (C, 39.7, 1)	High	1.73
	Loon Cr.	Idaho Batholith	Spring & Sum	Basic (C, 39.6, 3)	Med	2.36
	Camas Cr.	Idaho Batholith	Spring	Basic (B, 37.4, 3)	Med	2.53
	Lower Middle Fk tribs	Idaho Batholith	Spring	Basic (A, 29.3, 2)	Low	1.15
	Sulphur Cr.	Idaho Batholith	Spring	Basic (A, 16.1, 1)	High	1.21
Upper Salmon River	Lemhi R.	Middle Rockies	Spring	**Large (B, 183.4, 10)**	Med	2.31
	Upper Salmon & Tribs	Idaho Batholith	Spring	***Inter. (D, 79.8, 3)***	High	2.48
	Pahsimeroi R.	Middle Rockies	Summer	***Inter. (C, 138.6, 6)***	High	1.05
	Upper Salmon Lower	Blue Mountains/	Spring & Sum	***Inter. (136.9, 12)***	Med	3.65
	Panther Cr. **	Idaho Batholith	Spring	Basic (C, 53.2, 4)	Med	
	East Fk Salmon R.	Middle Rockies	Spring & Sum	Basic (A, 52.4, 4)	Med	2.18
	North Fk Salmon	Idaho Batholith	Spring	Basic (D, 44.9, 3)	Low	3.17
	Valley Cr.	Idaho Batholith	Spring	Basic (A, 44.0, 1)	High	2.63
	Yankee Fork	Idaho Batholith	Spring	Basic (C, 29.0, 1)	Med	2.61

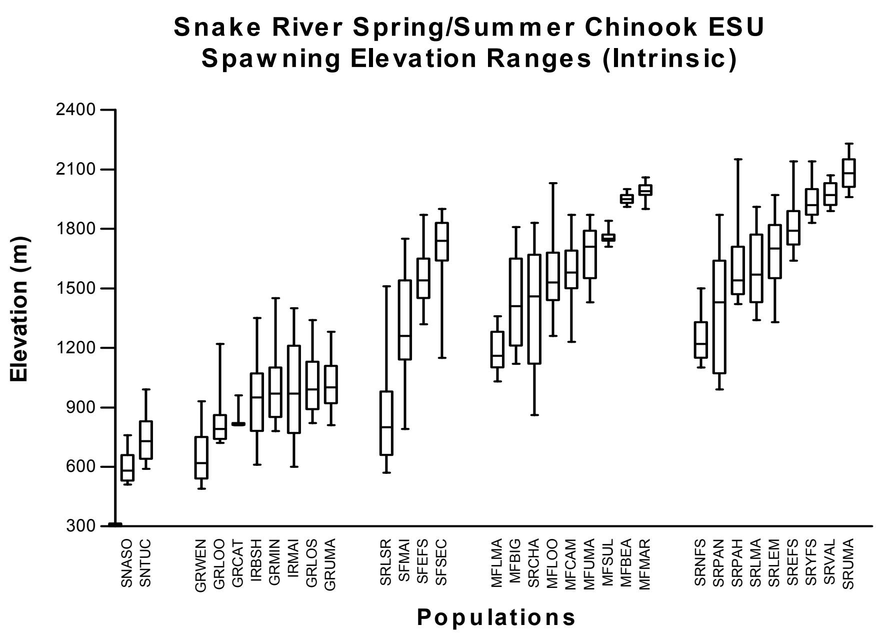


Figure E-1

Table E-2: Summary of population characteristics by Major Population Grouping

Upper Columbia Spring Chinook ESU

Major Grouping	Populations	Dominant Ecoregion	Life History Types (Adults)	Spawning (complex***, length, HUC5s)	Valley/stream width ratio	Current Diversity Index*
	Wenatchee R.	North Cascades	Spring	**Large (B, 249.8, 5)**	Med	2.47
	Methow R.	North Cascades	Spring	**Large (B, 198.8, 7)**	Med	3.10
	Entiat R.	North Cascades	Spring	Basic (A, 47.8, 1)	Med	0.58
	Okanogan R.**					

* "Current Diversity" column numbers are described in Attachment D.
** Extirpated
*** "A" = Simple; "B" = Dendritic; "C" = Trellis; "D" = Core + small tribs

Figure E-2

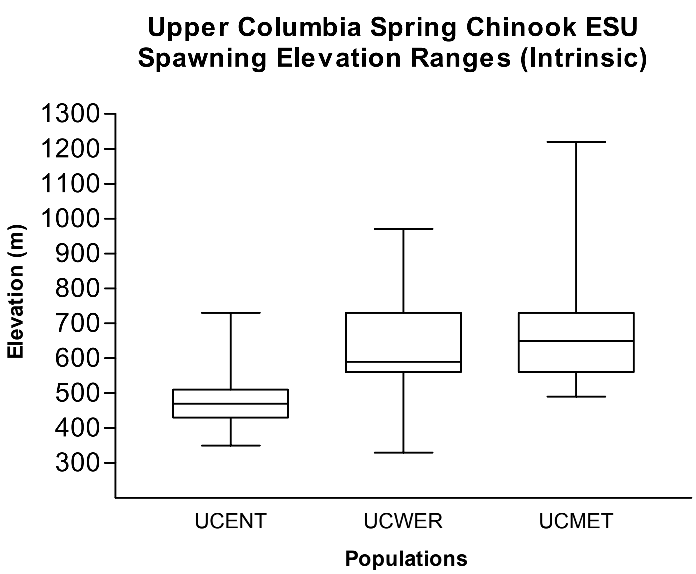


Table E-3: Summary of population characteristics by Major Population Grouping

Upper Columbia Steelhead ESU

Major Grouping	Populations	Dominant Ecoregion	Life History Types (Adults)	Spawning (complex***, length, HUC5s)	Valley/stream width ratio	Current Diversity Index*
	Wenatchee R.	North Cascades		***Inter. (B, 601.3, 5)***	med	2.76
	Methow R.	North Cascades		***Inter. (B, 662.3, 7)***	med	3.00
	Entiat R.	North Cascades		Basic (A, 149.3, 1)	med	1.44
	Okanogan R.??**			***Inter. (398.2, 5)***	med	0.74

* "Current Diversity" column numbers are described in Attachment D.

** Extirpated ??

*** "A" = Simple; "B" = Dendritic; "C" = Trellis; "D" = Core + small tribs

Figure E-3

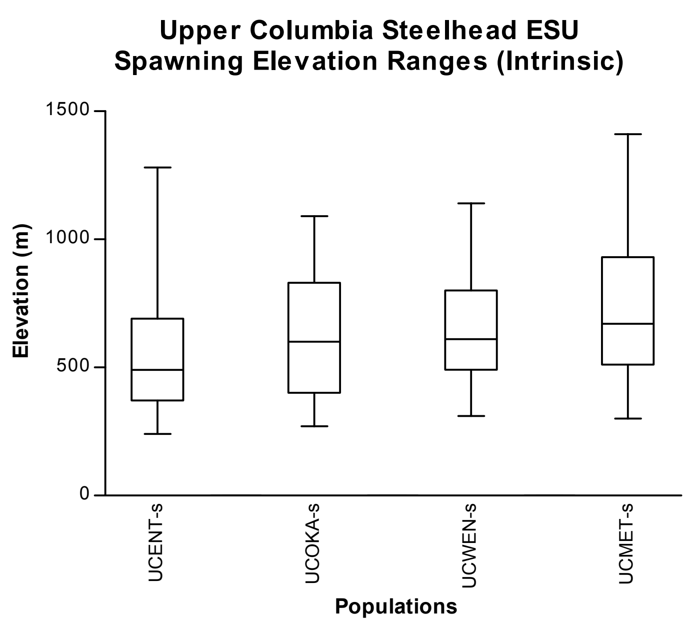


Table E-4: Summary of population characteristics by Major Population Grouping

Middle Columbia Steelhead ESU

Cascades Eastern Slope Tributaries	Klickitat	Eastern Cascades	Sum & Win	**Large (B, 843.0, 5)**	med	2.16
	Fifteen Mile	Eastern Cascades	Sum & Win	***Inter. (C, 364.9, 4)***	med	1.91
	Deschutes (East)	Columbia Plateau	Summer	***Inter. (B, 457.7, 7)***	low	2.85
	Deschutes (West)	Blue Mountains	Summer	***Inter. (B, 465.0, 4)***	med	2.87
	White Salmon**	Eastern Cascades	Summer??	***Inter. (A?, 250.1, 2)***	med	1.28
	Rock Creek	Eastern Cascades	Summer	Basic (A?, 108.0, 1)	med	1.40
John Day Drainage	Lower Mainstem tribs	Blue Mountains	Summer	**Large (B, 1404.4, 16)**	low	4.04
	North Fork John Day	Blue Mountains	Summer	**Large (B, 1051.8, 10)**	med	3.62
	Middle Fork John Day	Blue Mountains	Summer	***Inter. (B, 430.5, 5)***	med	2.56
	South Fork John Day	Blue Mountains	Summer	***Inter. (B, 270.1, 4)***	med	2.59
	Upper Main John Day	Blue Mountains	Summer	***Inter. (498.8, 6)***	med	3.26
Umatilla/Walla Walla	Umatilla R.	Columbia Plateau	Summer	**Large (B, 1012.5, 9)**	med	2.14
	Walla-Walla R.	Columbia Plateau	Summer	***Inter. (B, 582.4, 6)***	med	2.46
	Touchet R.	Columbia Plateau	Summer	***Inter. (A, 393.7, 5)***	med	1.87
Yakima Drainage	Naches R.	Eastern Cascades	Summer	**Large (B, 762.6, 4)**	med	2.75
	Yakima R. Upper Main	Columbia Plateau	Summer	**Large (B, 1195.1, 4)**	med	2.96
	Satus/Toppenish R.	Columbia Plateau	Summer	***Inter. (B, 565.8, 2)***	med	1.79

* "Current Diversity" column numbers are described in Attachment D.

** Extirpated (Conduit dam)

*** "A" = Simple; "B" = Dendritic; "C" = Trellis; "D" = Core + small tribs

Figure E-4

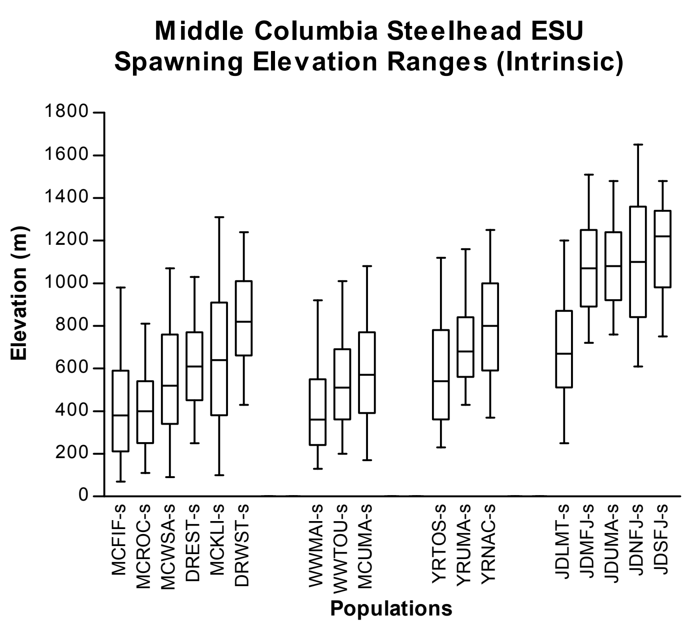


Table E-5: Summary of population characteristics by Major Population Grouping

Snake R. Steelhead ESU

Major Grouping	Populations	Dominant Ecoregion	Life History Types (Adults)	Spawning (complex***, length, HUC5s)	Valley/stream width ratio	Current Diversity Index*
Lower Snake Mainstem Tribs	Tucannon R.	Columbia Plateau	A type	***Inter. (A, 282.5, 3)***	med	2.68
	Asotin R.			***Inter. (D, 475.4, 5)***	med	1.46
Grande Ronde/Imnaha	Upper Grande Ronde	Blue Mountains	A type	**Large (B, 1122.5, 11)**	med	3.12
	Wallowa R.			***Inter. (B, 425.2, 6)***	med	2.61
	Joseph Cr.			***Inter. (B, 284.1, 3)***	low	1.94
	Lower Grande Ronde			***Inter. (B, 635.9, 5)***	low	2.76
	Imnaha River			***Inter. (B, 552.5, 5)***	low	3.00
Clearwater R.	Lower Mainstem	Northern Rockies	A type	**Large (B, 954.9, 14)**	med	2.99
	Selway		B type	**Large (B, 859.3, 11)**	low	3.51
	North Fork (ext)	Idaho Batholith	---	**Large (?, 1422.4, 17)**	low	0.00
	Lochsa R.		B type	***Inter. (B, 636.7, 7)***	med	2.83
	South Fork		???	***Inter. (B, 541.9, 7)***	med	2.73
	Lolo Cr.		A and B types	Basic (C, 161.2, 1)	med	2.31
South Fork Salmon R.	Lower Middle Fk.	Idaho Batholith	B type	**Large (?, 734.8, 12)**	low	3.04
	Upper Middle Fk.			***Inter. (B, 633.7, 9)***	med	3.39
	Upper Mainstem			***Inter. (B, 545.0, 8)***	med	2.65
	Lemhi R.	Middle Rockies	B type	***Inter. (B, 530.7, 9)***	med	2.76
	South Fork Salmon	Idaho Batholith		***Inter. (B, 422.4, 4)***	med	2.91
	Little Salmon/tribs	Blue Mountains	A type	***Inter. (D, 416.7, 7)***	low	4.19
	Chamberlain Cr./tribs	Idaho Batholith	A type	***Inter. (D, 405.1, 7)***	low	3.02
	Panther Cr.			***Inter. (D, 393.9, 6)***	low	2.79
	East Fk Salmon	Idaho Batholith	B type	***Inter. (B, 390.8, 7)***	med	2.39
	Pahsimeroi R.			***Inter. (C, 354.1, 6)***	med	2.05
	North Fk Salmon			Basic (D, 181.0, 3)	low	3.37
	Secesh R.	Idaho Batholith		Basic (C, 159.1, 1)	med	2.46
	Hells Canyon tribs	Blue Mountains	A type	Basic (D, 103.3, 2)	low	1.62

* "Current Diversity" column numbers are described in Attachment D.
*** "A" = Simple; "B" = Dendritic; "C" = Trellis; "D" = Core + small tribs

Figure E-5